

**Before the  
Federal Communications Commission  
Washington, D.C. 20554**

In the Matter of	)	
	)	
Expanding the Economic and Innovation	)	GN Docket No. 12-268
Opportunities of Spectrum Through Incentive	)	
Auctions	)	
	)	
Office of Engineering and Technology Releases	)	ET Docket No. 13-26
and Seeks Comment on Updated OET-69	)	
Software	)	
	)	
Office of Engineering and Technology Seeks to	)	ET Docket No. 14-14
Supplement the Incentive Auction Proceeding	)	
Record Regarding Potential Interference Between	)	
Broadcast Television and Wireless Services	)	

**SECOND REPORT AND ORDER AND  
FURTHER NOTICE OF PROPOSED RULEMAKING**

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By the Commission: Commissioner Pai issuing a statement.

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## I. INTRODUCTION

1. We address several outstanding issues related to the *Incentive Auction R&O* in this item.<sup>1</sup> First, we address and reject proposals for additional limits on any new interference between television

<sup>1</sup> See *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Report and Order, 29 FCC Rcd 6567 (2014) (*Incentive Auction R&O*).

stations as result of the repacking process.<sup>2</sup> Second, we establish a methodology and the associated input values to predict inter-service interference between television and wireless services in certain areas for use during the incentive auction (ISIX Methodology).<sup>3</sup> Third, we propose a post-auction inter-service interference methodology and input values, as well as protection standards for any television stations and new 600 MHz Band wireless services on co- or adjacent-channel frequencies in nearby areas.<sup>4</sup> As explained below, the principal difference between the methodology we adopt for auction use and the one we propose for use after the auction is that the latter will be based on actual 600 MHz Band wireless network deployments, whereas the former requires assumptions because networks will not be deployed yet.

## II. SECOND REPORT AND ORDER

### A. Requested Additional Limits on New Interference in the Repacking Process

2. We decline to establish a one-percent cap on the amount of total or aggregate new interference that a broadcast station will be allowed to receive from other stations, as requested by the National Association of Broadcasters (NAB) and others. In the *Incentive Auction R&O*, the Commission adopted a 0.5 percent limit on new interference that will be applied on a pairwise or station-to-station basis.<sup>5</sup> We conclude that broadcasters' concerns regarding the potential for new interference in the absence of a separate one-percent cap on aggregate interference are exaggerated: the vast majority of stations are unlikely to experience aggregate new interference of more than one percent. We are also adopting measures that will effectively address broadcasters' concerns about such interference in exceptional cases where there may be aggregate new interference of more than one percent. In addition to being unnecessary, the proposed cap is not practical or realistic, because even if the broadcasters had identified a means of implementing it (they have not), an aggregate interference cap would deprive the reverse auction bidding process of its speed and, therefore, compromise the success of the incentive auction. We conclude that we can fulfill Congress's mandate to make "all reasonable efforts" to preserve the population served of stations that will remain on the air after the incentive auction without imposing an aggregate interference cap.<sup>6</sup> Crucially, we can do so in a manner that ensures an efficient channel assignment scheme, minimizes repacking costs and disruption to broadcasters and viewers, and furthers our goal of a successful auction. For the reasons discussed below, we also decline to adopt an additional limit on new interference to stations that are currently experiencing ten percent or more interference within their service areas.

#### 1. Background

3. Section 6403(b)(2) of the Spectrum Act requires the Commission, in reorganizing or "repacking" the broadcast television bands, to "make all reasonable efforts to preserve, as of [February 22, 2012], the coverage area and population served" of eligible television stations.<sup>7</sup> In the *Incentive Auction R&O*, the Commission interpreted this mandate to require "that we use all reasonable efforts to preserve each station's coverage area and population served without sacrificing the goal of using market

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<sup>2</sup> See *id.* at 6651, para. 182. We adopted a 0.5 percent "pairwise" or station-to-station limit on any new interference as a result of the repacking process in the *Incentive Auction R&O*. See *id.* at 6649-51, paras. 179-81.

<sup>3</sup> See *id.* at 6605-6, paras. 82-84. We will address the specific uses to be made of the interference predictions in the forthcoming *Comment PN* on final auction procedures. See *infra* note 79.

<sup>4</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6605-6, paras. 82-84. The "600 MHz Band" refers to UHF spectrum that will be repurposed for new, flexible uses following the incentive auction. See *id.* at 6571, para. 5.

<sup>5</sup> See *id.* at 6649, para. 178.

<sup>6</sup> See Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, § 6403(b)(2) (codified at 47 U.S.C. § 1452), 126 Stat. 156 (2012) (Spectrum Act).

<sup>7</sup> *Id.*

forces to repurpose spectrum for new, flexible uses.”<sup>8</sup> Consistent with that interpretation, the Commission adopted an approach to preserving population served under which no channel assignment, “considered alone, may reduce another station’s specific population served by more than 0.5 percent.”<sup>9</sup> The Commission’s rules treat 0.5 percent interference or less as *de minimis* or no new interference, as this amount rounds to zero at integer precision.<sup>10</sup> Under this approach, the Commission will only consider station-to-station (or “pairwise”) interference when determining whether a particular channel assignment is permissible.

4. While most commenters, including the broadcast industry, supported the Commission’s approach to pairwise interference, NAB, supported by other broadcasters, urged the Commission to adopt two additional measures.<sup>11</sup> First, NAB asked that the Commission cap the amount of total new interference that a station may receive at one percent.<sup>12</sup> According to NAB, “while an individual station can only cause a maximum addition of 0.5 percent interference . . . , ‘stations repacked during the incentive auction process . . . would likely receive interference from multiple stations’ which, in the aggregate, could ‘lead to significant viewer losses.’”<sup>13</sup> Second, noting that some stations currently receive up to ten percent interference, NAB requested that the Commission prevent any new interference to these stations.<sup>14</sup> The Commission deferred a decision on these proposals, explaining that FCC staff would be “releasing a Public Notice inviting comment on a staff analysis of the potential impact of aggregate interference on television stations as a result of the repacking process,” and that the Commission would resolve the issue in a subsequent order.<sup>15</sup>

5. The staff released its analysis on June 2, 2014.<sup>16</sup> The *Aggregate Interference PN* explained that the staff analysis was based on updated “constraint files” for each station developed using the repacking approach adopted in the *Incentive Auction R&O*, including the pairwise approach to preserving population served.<sup>17</sup> Using these constraint files, the staff conducted 100 simulations of the

<sup>8</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6622-23, para. 122. See *id.* at 6623-24, para. 123.

<sup>9</sup> *Id.* at 6649, para. 178.

<sup>10</sup> *Id.* at 6649, para. 178 n.598.

<sup>11</sup> *Id.* at 6651, para. 182. See Comments of the National Association of Broadcasters, GN Docket No. 12-268 at 20-21 (filed Jan. 25, 2013) (NAB NPRM Comments); see also Comments of ABC Television Affiliates Association et al., GN Docket No. 12-268 at 3 (filed Jan. 25, 2013); Comments of Univision Communications, GN Docket No. 12-268 at 7 (filed Jan. 25, 2013); Comments of Belo Corp., GN Docket No. 12-268 at 14-15 (filed Jan. 25, 2013); Comments of Tribune Co., GN Docket No. 12-268 at 17 (filed Jan. 25, 2013); Comments of the Broadcast Networks, GN Docket No. 12-268, at 7 (filed Jan. 25, 2013) (Broadcast Networks NPRM Comments); Reply Comments of the National Association of Broadcasters, GN Docket No. 12-268 at 43-44 (filed Mar. 12, 2013).

<sup>12</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6651, para. 182. See NAB NPRM Comments at 20-21; Comments of ABC Television Affiliates Association at 3 (filed Jan. 25, 2013); Comments of Univision Communications at 7 (filed Jan. 25, 2013); Comments of Belo Corp. at 14-15 (filed Jan. 25, 2013); Reply Comments of the National Association of Broadcasters at 43-44 (filed Mar. 12, 2013).

<sup>13</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6651, para. 182 (quoting NAB NPRM Comments at 20-21).

<sup>14</sup> NAB NPRM Comments at 21.

<sup>15</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6651, para. 182.

<sup>16</sup> *Incentive Auction Task Force Releases Updated Constraint File Data Using Actual Channels and Staff Analysis Regarding Pairwise Approach to Preserving Population Served*, GN Docket No. 12-268, ET Docket No. 13-26, Public Notice, 29 FCC Rcd 5687 (June 2, 2014) (*Aggregate Interference PN*).

<sup>17</sup> The updated constraint files were released in conjunction with the *Aggregate Interference PN*. Each constraint file includes a “domain” file and an “interference-paired” file. See *Incentive Auction R&O*, 29 FCC Rcd at 6619-20, para. 114. See also *infra* para. 8. The updated constraint files were based on calculations of the coverage of a station and the interference between stations replicated on “actual channels,” or every possible channel that could be (continued....)

repacking process, based on two different spectrum recovery scenarios (84 MHz and 126 MHz) and applying several different approaches to select which stations went off the air as a result of the reverse auction, producing a channel assignment plan for each simulation.<sup>18</sup> The staff then calculated the aggregate or total predicted new interference from all stations to each station's population served for every channel plan.<sup>19</sup> Across all of the simulations, no station was predicted to receive aggregate new interference of two percent or more.<sup>20</sup> One percent of stations were predicted to receive aggregate new interference between one and two percent, while the vast majority of stations (approximately 88 percent) were predicted to receive aggregate new interference of well under the 0.5 percent *de minimis* threshold.<sup>21</sup>

## 2. Discussion

### a. Stations are Highly Unlikely to Experience Aggregate Interference of More than One Percent

6. Broadcasters' concerns regarding the potential for aggregate new interference to more than one percent of their viewers in the absence of a cap are overstated: the vast majority of stations are unlikely to experience significant new interference as a result of the repacking process. NAB points to a sample New York station which has seven stations causing some unique, non-overlapping interference, arguing that without a cap this station could receive new aggregate interference of two to three percent as a result of the repacking process.<sup>22</sup> However, NAB's analysis includes existing patterns of interference—that is, areas in which viewers do not currently receive service from a station due to interference from other stations—which our repacking approach does not consider in seeking to preserve population served.<sup>23</sup> Staff analysis applying the repacking approach adopted in the *Incentive Auction R&O* predicts that the overwhelming majority of stations (approximately 99 percent) will not experience new interference above the proposed cap.<sup>24</sup> Only one percent of all stations were predicted to receive aggregate new interference between one and two percent, with no station predicted to receive two percent or greater.<sup>25</sup> In addition, the vast majority of stations (approximately 88 percent) across all 100 simulations conducted by the staff were predicted to receive new interference from all stations of well under the 0.5 percent *de minimis* threshold. These results indicate that the station-to-station or pairwise approach to preserving population served that the Commission adopted in the *Incentive Auction R&O* is sufficiently conservative to prevent the crowded market scenario that concerns NAB.

(Continued from previous page)

assigned to a station during the repacking process (as opposed to a single proxy channel). See *Aggregate Interference PN*, 29 FCC Rcd at 5689.

<sup>18</sup> *Aggregate Interference PN*, 29 FCC Rcd at 5204-04, Appendix. Because the amount of spectrum recovered in the incentive auction depends on a number of factors, *Incentive Auction R&O* adopted a 600 MHz Band Plan that includes a number of specific band plans for different spectrum recovery scenarios. See *Incentive Auction R&O*, 29 FCC Rcd at 7018-25, App. C, paras. 117-40.

<sup>19</sup> In response to a subsequent request by NAB, the staff released the raw results of its full simulations. See Letter from Gary Epstein, Chair, Incentive Auction Task Force, to Rick Kaplan, Executive Vice President, Strategic Planning, NAB, GN Docket No. 12-268, ET Docket No. 13-26 (filed June 30, 2014). These results are also available on the LEARN website, <http://fcc.gov/learn>, under the Repacking section, or directly at [http://data.fcc.gov/download/incentive-auctions/Simulation\\_Results/](http://data.fcc.gov/download/incentive-auctions/Simulation_Results/).

<sup>20</sup> *Aggregate Interference PN*, 29 FCC Rcd at 5705-08, Appendix.

<sup>21</sup> *Id.* The remaining 11 percent of stations were predicted to receive between 0.5 and 1 percent aggregate new interference.

<sup>22</sup> See NAB NPRM Comments at 30.

<sup>23</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6646-47, para. 172.

<sup>24</sup> *Aggregate Interference PN*, 29 FCC Rcd at 5706-08, Appendix.

<sup>25</sup> *Id.*

7. NAB argues that anomalies in the data underlying the staff analysis call its validity into question, and that the results are skewed because the staff failed to analyze scenarios in which less than 84 MHz of spectrum is repurposed.<sup>26</sup> As discussed below, these arguments lack merit. The alleged anomalies do not represent errors or inconsistencies in the data on which the staff relied. Further, the argument that the results are skewed is based on a mistaken premise: that the risk of higher levels of new aggregate interference would be higher if the incentive auction were to recover less spectrum. In actuality, the constraints adopted in the *Incentive Auction R&O* to preserve coverage area and population served limit how stations may be repacked and will not vary depending on the amount of spectrum recovered.

8. *Accuracy of the Underlying Data.* NAB questions the accuracy of the staff analysis based on purported anomalies in the underlying data.<sup>27</sup> The updated constraint files underlying the staff analysis consist of two files for each television station: a “domain” file that lists all of the channels to which the station could be assigned considering fixed constraints, and an “interference-paired” file that lists all of the other stations that could *not* be assigned to operate on the same or on an adjacent channel with that station (because the stations’ interference relationship would violate the 0.5 percent new pairwise interference threshold).<sup>28</sup> NAB points to two examples in which the files reflect that two or more stations cannot be assigned to the same channel on certain frequencies, but may be assigned to the same channel on nearby frequencies.<sup>29</sup> According to NAB, these “results appear highly unlikely given that . . . the change in the amount of interference caused between assigning closely spaced channels . . . is not significant.”<sup>30</sup> The examples NAB identifies represent neither an error nor an inconsistency in the underlying data. These results simply demonstrate that predicted interference will change slightly as stations move from one channel to another because radio waves propagate differently on different frequencies.<sup>31</sup> The slight variations may result in situations where stations cannot operate on one channel under the applicable constraints, but may operate on a nearby channel, because such variations cause the interference relationship between two stations to go above or below the 0.5 percent interference threshold.

9. In the first example identified by NAB, study station 35862 cannot operate co-channel with a number of other undesired stations if the pair of stations are assigned channels 39 through 44, but can operate co-channel with the same stations if the pair are assigned channels 38 or 45.<sup>32</sup> In this example, one of study station 35862’s two-by-two kilometer grid cells<sup>33</sup> changed from “no interference” to “interference” across different channels as a result of interference from undesired station 35380. This particular grid cell is located near the edge of station 35862’s interference-free population area, where

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<sup>26</sup> See Comments of the National Association of Broadcasters, GN Docket No. 12-268 (filed July 2, 2014) (NAB Aggregate Interference PN Comments); see *supra* note 18.

<sup>27</sup> NAB Aggregate Interference PN Comments at 7-8 (“The aggregate results, however, are based on an interference paired file containing possible errors that could affect the generation of these repacking scenarios and ultimately the aggregate interference results.”).

<sup>28</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6619-20, para. 114. Fixed constraints are “incumbents in the bands other than domestic television stations that are entitled to interference protection at fixed geographic locations and on specific channels. *Id.*”

<sup>29</sup> NAB Aggregate Interference PN Comments at 3-6.

<sup>30</sup> NAB Aggregate Interference PN Comments at 4.

<sup>31</sup> The predicted interference may change as either the “desired station” (*i.e.*, the station receiving interference, also referred to as the “study” station) or the “undesired station” (*i.e.*, the station causing interference) changes channels.

<sup>32</sup> NAB Aggregate Interference PN Comments at 4.

<sup>33</sup> A station’s service area is divided into approximately square grid cells to evaluate signal strength, or coverage, and any interference for purposes of the repacking analysis. See *Incentive Auction R&O*, 29 FCC Rcd at 6626-27, para. 131.

small changes in desired-to-undesired (D/U) signal strength ratios can affect whether or not interference is predicted.<sup>34</sup> Because this cell has a relatively large population,<sup>35</sup> it alone can raise study station 35862's interfered-with population above the 0.5 percent interference threshold. On channels 38 and 45, the predicted interference between these two stations was essentially zero percent, as this particular cell's population was not counted as interfered-with. On channels 39-44, however, this cell's D/U ratio changed enough that its population was counted as interfered-with, thereby raising the predicted interference to just above the threshold (to 0.53 percent).

10. In the second example cited by NAB, station 125 can operate on channels 2, 3, 7, 8, 9, or 10, but not on channels 5, 11, or 12, when station 63158 operates on the upper adjacent channel.<sup>36</sup> Moreover, station 63158 cannot operate on any lower adjacent channel to station 125.<sup>37</sup> A constraint is created if the 0.5 percent interference threshold is violated in either direction (*i.e.*, from station A to station B, or from station B to station A).<sup>38</sup> Similar to the first example, a slight increase in interference results from a very small number of study station 63518's grid cells near the edge of its interference-free population changing from "no interference" to "interference" when station 63518 operates on channel 12 rather than channel 11 (and undesired station 125 operates on channel 11 rather than channel 10). In this case, three cells had populations significant enough to cause the interfered-with population to rise above the interference threshold (from 0.45 to 0.59 percent). Although station 125 on channel 11 is not predicted to *receive* interference above the threshold from station 63158 on channel 12, it is predicted to *cause* interference above the threshold to station 63158. Thus, NAB's examples do not reflect inconsistencies or errors in the updated constraint files underlying the staff analysis.

11. *Robustness of the Studies.* We also reject NAB's claims that the staff analysis is skewed by the spectrum recovery scenarios studied and understates the potential for new aggregate interference. Arguments that lower levels of broadcaster participation in the reverse auction (resulting in less spectrum recovered) increase the potential for new aggregate interference in crowded markets are based on a misunderstanding of the repacking process. In the 84 and 120 MHz scenarios studied by the staff, higher levels of participation are required because more stations would have to voluntarily relinquish their spectrum usage rights in order for the Commission to be able to repack the remaining stations consistent with the constraints adopted in the *Incentive Auction R&O*. In other words, more stations would have to go off the air because fewer channels would be available in the TV spectrum to repack broadcasters. If, on the other hand, fewer broadcasters choose to participate, as NAB contends is likely, the pairwise constraints would prevent the auction from repurposing as much spectrum, leaving more television

<sup>34</sup> The desired-to-undesired channel ratio (D/U ratio) is a function of the predicted propagation of signals of either the desired station or the undesired station on different channels. At the edge of a station's contour where a desired station's signal is weaker, small predicted propagation changes and the interaction between overlapping signals are more likely to cause a D/U ratio to fall below the applicable thresholds, even for a one-channel difference.

<sup>35</sup> This particular cell has a population of ten thousand people; station 35862 has an interference-free population of 1.933 million people.

<sup>36</sup> NAB Aggregate Interference PN Comments at 5. The "upper adjacent channel" refers to the channel immediately above a given channel in frequency. For example, Channel 3 is the "upper adjacent channel" with respect to Channel 2.

<sup>37</sup> See NAB Aggregate Interference PN Comments at 5-6. The "lower adjacent channel" refers to the channel immediately below a given channel in frequency. For example, Channel 3 is the "lower adjacent channel" with respect to Channel 4.

<sup>38</sup> See *Repacking Data PN*, 28 FCC Rcd at 10400-01. Interference between a pair of stations is generally not symmetric: the interference station B is predicted to cause to station A is not necessarily the same as the interference station A is predicted to cause to station B. *Id.* In determining whether stations can co-exist in a particular channel relationship, predicted interference in both directions must be examined. *Id.* This approach of identifying constraints regardless of whether the constraint results from causing or receiving interference makes analyzing the constraint files easier for individual stations by avoiding the need to analyze inverse relationships.

channels available to assign to stations.<sup>39</sup> Regardless of how much spectrum is recovered, the constraints remain static throughout the auction, and provide limits to whether and how stations may be repacked.<sup>40</sup>

12. The results of the staff's analysis were consistent across broadcaster participation rates, which ranged from 80 to 100 percent, and across a large (36 MHz) difference in the two spectrum recovery scenarios studied.<sup>41</sup> This consistency confirms that lower levels of broadcaster participation—and scenarios in which less spectrum is recovered—will not have a significant impact on new aggregate interference. The staff's approach to selecting the stations to voluntarily go off the air in the simulations also ensured that virtually every station was part of at least one simulation in which that station remained on the air.<sup>42</sup> Accordingly, we reject NAB's contention that the results of the staff analysis are unreliable.<sup>43</sup>

13. *Release of Simulation Software.* We reject contentions that the *Aggregate Interference PN* comment period was too short and that meaningful comment on the staff analysis was impossible without access to the simulation software that the staff used to generate constraint files and perform feasibility checks.<sup>44</sup> The *Aggregate Interference PN* provided 30 days for comments and an additional 20 days for reply comments, and parties have had additional time to analyze the study (and to submit *ex parte* filings) since the comment period closed. Ample information has been made publicly available to allow for meaningful input on the staff analysis and its results, including the methodology, data, and assumptions underlying the analysis. Moreover, in the interest of transparency and encouraging meaningful input, the Commission and its staff have made extensive information about the repacking process publicly available over the course of this proceeding.<sup>45</sup> The data and methodology required to simulate repacking scenarios were first detailed more than a year ago in the *Repacking Data PN*.<sup>46</sup> The staff provided technical detail about how software could be used to perform “feasibility checks” (that is, to determine whether channels can be assigned to all of the stations eligible for protection in the repacking process consistent with the constraints imposed by the Spectrum Act) in January 2014,<sup>47</sup> and

<sup>39</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6709, para. 328.

<sup>40</sup> Hypothetically, the recovery of more spectrum could lead to stations being repacked more “tightly,” in the sense that the final channel assignment scheme may contain fewer vacant channels in major markets because the remaining TV bands are smaller. Due to the pairwise constraints, such an outcome would not result from low participation rates in the reverse auction, however. Contrary to NAB's argument, aggregate new interference of more than one percent is *less* likely under scenarios in which the incentive auction recovers less spectrum than 84 or 126 MHz, due to the greater number of channels that would be available in the remaining TV bands.

<sup>41</sup> *Aggregate Interference PN*, 29 FCC Rcd at 5706-08, Appendix. NAB suggests that the staff conduct simulations with participation rates ranging from 10 to 100 percent. NAB *Aggregate Interference PN* Comments at 8.

<sup>42</sup> As can be determined from the raw results released by the staff, *see supra* note 19, across all 100 simulations, 99.78 percent of stations were selected by the simulation algorithm to be remain on-air as part of a repacked channel plan in at least one scenario.

<sup>43</sup> NAB *Aggregate Interference PN* Comments at 7. NAB's suggestion that the staff analysis is incomplete because it pertains only to preserving population served, and not preserving coverage area, *see* NAB *Aggregate Interference PN* Comments at 9, lacks merit. The purpose of the analysis was limited to studying the potential for new aggregate interference under the constraints established in the *Incentive Auction R&O* for preserving population served. We established different constraints to preserve coverage area. *See Incentive Auction R&O*, 29 FCC Rcd at 6568-69, para. 166; *see also Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Declaratory Ruling, FCC 14-143, para. 5 (September 30, 2014).

<sup>44</sup> NAB *Aggregate Interference PN* Comments at 3, 9; *see* Reply Comments of Cohen, Dippell, and Everist, P.C. (filed July 22, 2014); Letter from Preston Padden, Executive Director, Expanding Opportunities for Broadcasters Coalition, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268 (filed June 30, 2014).

<sup>45</sup> *See Incentive Auction R&O*, 29 FCC Rcd at 6633-34, para. 143.

<sup>46</sup> *See Repacking Data PN*, 28 FCC Rcd at 10375-411, Technical Appendix.

<sup>47</sup> *See Feasibility Checking PN*, 29 FCC Rcd at 51-53, Appendix.

further detailed the staff's repacking simulation software in a subsequent workshop.<sup>48</sup> Thus, interested parties have had sufficient time and information to comment meaningfully on the staff analysis.<sup>49</sup>

**b. Measures to Address Aggregate Interference of More than One Percent in Exceptional Cases**

14. We adopt two measures to address exceptional cases where a station is predicted to receive aggregate new interference in excess of one percent. First, we will use optimization techniques that seek to avoid final channel assignments that would result in aggregate new interference of more than one percent. After the incentive auction bidding closes and the set of stations that will remain on the air in each band is established, we plan to employ optimization techniques to determine a final channel assignment scheme from the provisional channel assignments identified during the reverse auction bidding process.<sup>50</sup> During this final channel assignment process, we can take time to account for factors in addition to feasibility, such as aggregate new interference, without compromising the speed of the reverse auction bidding process.<sup>51</sup> Among other objectives, we intend to seek a final channel assignment that minimizes new aggregate interference above one percent.<sup>52</sup> Although our current rules do not provide broadcasters with complete protection from aggregate interference caused by other broadcast stations, we choose a one percent threshold in light of broadcasters' stated concerns about aggregate interference exceeding this amount.<sup>53</sup>

15. Although we anticipate that this final channel assignment optimization procedure will further reduce the already-small number of stations that are predicted to receive new interference greater than one percent, we cannot guarantee this result in every case. The optimization procedure can identify the best final channel assignment scheme given the station-to-band assignments produced by the reverse auction. However, we cannot change these assignments after the bidding stops and the final stage rule is met without undoing the entire auction. Accordingly, as an additional safeguard, if a station is predicted to receive new interference above one percent on the final channel assigned to it following the repacking process, we will provide it with the opportunity to file an application proposing an alternate channel or expanded facilities in a priority filing window, along with a limited number of other stations that have been assigned the same priority.<sup>54</sup> This opportunity will be available to any station entitled to protection

<sup>48</sup> See LEARN Workshop on Feasibility Checking During Repacking Process, FCC (Feb. 21, 2014), *available at* <http://www.fcc.gov/events/learn-workshop-feasibility-checking-during-repacking-process>. Based on information released by the staff, at least two interested parties have conducted their own analyses in order to comment on the repacking approach. See Letter from Brian J. Benison, Director, Federal Regulatory, AT&T, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268 (filed June 17, 2014); Letter from Trey Hanbury, Counsel for T-Mobile, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268 (filed September 9, 2014).

<sup>49</sup> We note that we anticipate publicly releasing the source code to the software used to generate constraint files and perform feasibility checks in the future, consistent with our practice in this proceeding of releasing such information as appropriate in the interest of transparency and in consideration of the ongoing, internal deliberations regarding it.

<sup>50</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6621, para. 118.

<sup>51</sup> See *id.*

<sup>52</sup> We will seek comment in the upcoming *Comment PN* on additional final channel assignment optimization objectives, including minimizing relocation costs and reducing channel moves. *Id.*

<sup>53</sup> See NAB NPRM Comments at 20; see also Broadcast Networks NPRM Comments at 7.

<sup>54</sup> We established an application filing window in the *Incentive Auction R&O* for stations to propose alternate channels and expanded facilities following the repacking process. *Incentive Auction R&O*, 29 FCC Rcd at 6793, para. 553. We announced a filing priority for stations unable to construct facilities that meet the technical parameters specified for their new channel for reasons beyond their control. See 47 C.F.R. § 73.3700(b)(1)(iv) (providing a priority to stations that, for reasons beyond their control, cannot construct facilities that meet the technical parameters specified in the *Channel Reassignment Public Notice*); *Incentive Auction R&O*, 29 FCC Rcd at 6794, para. 554.

in the repacking process that is predicted to experience aggregate new interference in excess of one percent, regardless of whether that station was reassigned to a new channel in the repacking process. Taken together, the final channel assignment optimization procedure and post-assignment facilities modification processes will provide a “safety valve” in the exceptional cases where new aggregate interference above one percent has occurred or is likely to occur.<sup>55</sup>

**c. An Aggregate Cap Would Deprive the Reverse Auction Bidding Process of Its Speed and Threaten the Success of the Auction**

16. In addition to being unnecessary for the reasons described above, imposition of an aggregate interference cap would compromise the central objective of a successful auction that allows market forces to determine the highest and best use for spectrum.<sup>56</sup> Speed is critical to the successful implementation of the incentive auction: Our repacking methodology must be capable of analyzing complex technical issues fast enough to not unduly slow down the bidding process.<sup>57</sup> Under the repacking approach adopted in the *Incentive Auction R&O*, only one provisional channel assignment scheme that meets all of the constraints need be identified for the reverse auction bidding to proceed.<sup>58</sup> Tens of thousands of individual “feasibility checks” may need to be run in each bidding round, and examining interference relationships only on a “pairwise” or station-to-station basis is the only way to identify a “feasible” repack analysis quickly enough to meet our objectives for the reverse auction. As discussed above, we intend to account for factors beyond mere feasibility without compromising the bidding process by seeking to optimize provisional channel assignments after the bidding stops: once the set of stations that will remain on the air in each band after the auction is complete has been established, we intend to use optimization techniques to determine a channel assignment that limits the amount of aggregate new interference for any station.

17. It would be significantly more complicated and, as a result, time-consuming to consider the amount of aggregate interference from all sources that a station may receive on its provisional channel during the bidding process, as would be necessary to implement a cap on aggregate interference. Specifically, after the repacking process identifies a provisional channel assignment for a station that is feasible—based on the pairwise constraints—the aggregate interference of the provisional assignments for all of the other stations that may need to be assigned a channel (non-participating stations and stations that continue to participate in the bidding) would have to be determined in a separate step. If the cap were exceeded, then the assignment would have to be disallowed and a new assignment identified. This iterative process would have to be repeated until either a provisional channel assignment were found that satisfies the cap or all possible assignments were eliminated. The same analysis would need to be performed repeatedly for *each station* that continues to participate in the bidding process, leading to

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<sup>55</sup> Courts have repeatedly held that it is reasonable for the agency to rely on a waiver process to address any unforeseen shortcomings that might arise in specific instances. See *Vt. Pub. Serv. Bd. v. FCC*, 661 F.3d 54, 65 (D.C. Cir. 2011) (finding a waiver process provided a reasonable means to update stale line count data used in a model for determining universal service support); *Rural Cellular Association v. FCC*, 588 F.3d 1095, 1104 (D.C. Cir. 2009) (discussing, with approval, a waiver process used to provide certain wireless carriers additional support should an interim cap render support insufficient); *Rural Cellular Association v. FCC*, 685 F.3d 1083, 1095 (D.C. Cir. 2012) (same); *Alenco*, 201 F.3d at 622 (finding a single carrier’s reduced rate of return under an operating expenses cap “at most . . . presents an anomaly that can be addressed by a request for a waiver”).

<sup>56</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6570, para. 2.

<sup>57</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6618, para. 111 n.362 (“Broadcast stations may drop out of the [reverse auction] bidding or not participate in the first place if they must wait for days, weeks or even months to find out whether their bids are accepted. Excessively long reverse auction stages would also impose costs on bidders in the forward auction. Because closing the incentive auction requires completion of the final stage of both the forward and the reverse auction, the possibility of significant delay in the latter could discourage participation in the forward auction, as well.”).

<sup>58</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6621, para. 117.

possibly an exponential number of feasibility checks *for each round of the auction*. Such an approach would deprive the repacking feasibility checker of its speed and threaten the success of the incentive auction.<sup>59</sup>

18. Despite the results of the staff analysis discussed above, broadcasters argue that the Commission must adopt the proposed cap under the “all reasonable efforts” mandate because doing so would not significantly increase repacking constraints.<sup>60</sup> We disagree. As we explained in the *Incentive Auction R&O*, we interpret the statutory mandate in light of the other objectives of the Spectrum Act, including the goal of repurposing spectrum for new, flexible uses. Requiring steps that would impede our ability to conduct a successful auction would sacrifice this goal and therefore is not “reasonable” within the meaning of the statute given the results of the staff analysis discussed above.<sup>61</sup> As discussed above, we are adopting measures that will effectively address broadcasters’ concerns regarding aggregate new interference. We have not identified, and no commenter has suggested, a means of implementing the proposed cap without compromising the speed of the bidding process, which is critical to conducting a successful auction. Under the circumstances, we conclude that the statute does not require adoption of the proposed cap.<sup>62</sup>

19. We also reject NAB’s assertion that failure to adopt the proposed cap would undermine the voluntariness of the reverse auction.<sup>63</sup> We do not believe—and NAB has not demonstrated through record evidence—that the possibility of an increase in aggregate new interference, such as the remote possibility predicted in the staff study, would so devalue a broadcaster’s license (or increase its costs) that it would coerce a broadcaster to participate in the auction.<sup>64</sup>

#### **d. Proposed Cap on Any New Interference to Certain Stations**

20. We also decline NAB’s suggestion to adopt a cap on any new interference to stations that are currently experiencing ten percent or more interference within their service areas.<sup>65</sup> As explained in

<sup>59</sup> Furthermore, even if it were possible to pre-calculate and store all possible cell-based interference data in a manner that could be quickly checked during the reverse auction, the satisfiability solvers that the staff have primarily used to conduct research on feasibility checking, *see Feasibility Checking PN*, 29 FCC at 51-52, Appendix, do not allow for constraints that are the sums of real variables, as would be needed for representing aggregate interference constraints.

<sup>60</sup> *See* Comments of Block Communications, Inc., GN Docket No. 12-268 at 3-4 (filed July 2, 2014); NAB Aggregate Interference PN Comments at 8-9 (“[I]f the staff is confident that its pool of 100 unique repacking scenarios is truly representative of likely auction outcomes, there is no reason *not* to adopt an aggregate interference cap that, according to the staff’s analysis, is extraordinarily unlikely to constrain the Commission’s ability to repack broadcast television stations.”).

<sup>61</sup> *See Incentive Auction R&O*, 29 FCC Rcd at 6622-25, paras. 120-26.

<sup>62</sup> *See, e.g., WildEarth Guardians v. Pub. Serv. Co. of Colorado*, 690 F.3d 1174, 1186-87 (10th Cir. 2012) (explaining that while “[i]t is possible [a utility] could have done more” to achieve Clean Air Act compliance, “doing so would have resulted in significant costs and delay” such that it was reasonable for the utility “to work towards . . . compliance while continuing construction”); *Grand Trunk Western R.R. Inc. v. Bhd. of Maint. of Way Employees*, 497 F.3d 568, 572 (6th Cir. 2007) (holding that “it would not be reasonable to require [the union] to engage in a third round of direct negotiations that are unlikely to success where to previous rounds of direct negotiation and mediation have failed”); *Price*, 416 F.3d at 1347-48 (11th Cir. 2005) (holding that it was unreasonable to require a libel plaintiff to depose seventeen individuals to identify a confidential informant when deposing the four women from whom he was most likely to discover the identity).

<sup>63</sup> *See* NAB NPRM Comments at 18-19 (arguing that, in the absence of a cap, “a station’s alternative to participation [would be] an uncertain future involving a forced relocation to another channel that might cause it greater interference (or increased cost, for that matter).”).

<sup>64</sup> *See Incentive Auction R&O*, 29 FCC Rcd at 6831, para. 647.

<sup>65</sup> NAB NPRM Comments at 21.

the *Incentive Auction R&O*, we interpret section 6403(b)(2) of the Spectrum Act “to require efforts to preserve service to those viewers who had access to a station’s signal within its protected coverage area as of” the statutory date.<sup>66</sup> Accordingly, we base comparative evaluations of interference on the population that a station was predicted to serve as of the statutory date.<sup>67</sup> Thus, the interference level that the stations in question were experiencing as of the statutory date is their baseline for repacking purposes. Adopting NAB’s suggestion would increase the constraints on the repacking process, hindering our ability to repack TV spectrum. In addition, we do not believe the statutory “all reasonable efforts” mandate warrants granting these stations greater interference protection than our current rules.<sup>68</sup> We therefore decline to treat these stations differently from other stations in the repacking process.

**e. Requested Cap on Viewer Losses Due to Channel Reassignments**

21. In a recent *ex parte* filing, NAB criticizes the staff’s analysis for ignoring potential terrain losses due to channel reassignments that could cause some stations to lose viewers,<sup>69</sup> and argues for the first time that the Commission must adopt “an aggregate cap on . . . the percentage decrease in population served as a result of repacking during the incentive auction process.”<sup>70</sup> We decline to address NAB’s new requested cap here.<sup>71</sup> Prior to NAB’s recent filing, no commenter proposed such a cap.<sup>72</sup> Rather, NAB and others advocated a cap on aggregate interference between stations,<sup>73</sup> and the purpose of the staff’s analysis was to study the potential for such interference.<sup>74</sup> The interference cap that NAB previously advocated would have no effect whatsoever on terrain losses, because such losses are not caused by interference between stations. Thus, NAB’s request for an aggregate cap on population loss is outside the scope of this item.

22. Although we decline to address NAB’s requested new cap here, consistent with our decision above to use optimization techniques to seek to avoid final channel assignments that would result in aggregate new interference of more than one percent,<sup>75</sup> we conclude that we should use optimization techniques to seek to avoid final channel assignments that would result in significant viewer losses due to

<sup>66</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6624, para. 124.

<sup>67</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6650, para. 180 (“[W]e agree with NAB and other broadcasters that section 6403(b)(2) of the Spectrum Act’s charge that we ‘make all reasonable efforts to preserve . . . the population served of each broadcast television licensee’ directs us to protect service to the specific viewers who had access to a station’s signal as of February 22, 2012. Interpreting the preservation mandate to refer to existing viewers as of this date seems most consistent with the statutory language and legislative history, as well as Commission precedent.”).

<sup>68</sup> 47 C.F.R. § 73.616. *See also supra* note 23.

<sup>69</sup> Letter from Rick Kaplan, Executive Vice President, Strategic Planning, NAB, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268, ET Docket No. 13-26 at 2 (filed September 24, 2014) (NAB 9/24/2014 Ex Parte); *see* Letter from Rick Kaplan, Executive Vice President, Strategic Planning, NAB, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268, ET Docket No. 13-26 (filed October 9, 2014); Letter from Patrick McFadden, Vice President, Strategic Planning, NAB, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268, ET Docket No. 13-26 (filed October 9, 2014).

<sup>70</sup> NAB 9/24/2014 Ex Parte at 2.

<sup>71</sup> We also decline to address here the additional issues raised in NAB’s recent *ex parte* filings, which are likewise unrelated to its proposed interference caps discussed above.

<sup>72</sup> The Affiliates Associations proposed a 0.5 percent cap on terrain losses or, alternatively, expanding station contours to compensate for terrain losses, but not a cap on any resulting viewer losses. *Incentive Auction R&O*, 29 FCC Rcd at 6645-46, para. 169.

<sup>73</sup> *See supra*, note [11].

<sup>74</sup> *See supra*, note [43].

<sup>75</sup> *See supra*, paras. [14-15].

terrain losses. We do not decide now on an optimization technique to carry out this objective, because unlike interference between stations, terrain losses can be avoided by optimizing for various factors. For example, minimizing channel moves will avoid terrain losses while also reducing broadcaster relocation costs, because a station that stays on the same channel will not experience terrain losses. Similarly, preferring moves to channels lower in the UHF band will avoid terrain losses while also serving the Commission's goal of repurposing UHF spectrum contiguously from channel 51 down.<sup>76</sup> We will seek comment on optimization factors for the final channel assignment scheme, including factors that would help both directly and indirectly to avoid final channel assignments that would result in significant viewer losses due to terrain losses, in the forthcoming *Incentive Auction Comment PN*.<sup>77</sup> Although different measures may be necessary to protect viewers from loss of service due to terrain losses and interference, consistent with the statutory mandate we will make all reasonable efforts to preserve television service to all existing viewers.

**B. ISIX Methodology and Input Values To Determine 600 MHz Band Wireless License Area Impairments During the Incentive Auction**

23. We adopt here the ISIX Methodology and input values proposed in the *ISIX PN*, with certain modifications, for use during the incentive auction.<sup>78</sup> The ISIX Methodology is set forth in detail in Appendix A (Technical Appendix). The ISIX Methodology and input values will be used during the auction to estimate the extent to which 600 MHz Band wireless license areas may be "impaired" due to predicted interference to, or from, broadcast television stations assigned to the 600 MHz Band as a result of market variation.<sup>79</sup> "Impaired" license areas may include "infringed" and/or "restricted" areas.<sup>80</sup> An "infringed" area is one where wireless operation is predicted to receive harmful interference from a television station that is placed in the 600 MHz Band. Wireless licensees will be free to operate in infringed areas, but will assume the risk of receiving interference from a television station.<sup>81</sup> A "restricted" area is one where wireless operations would be predicted to cause harmful interference to a television station that is placed in the 600 MHz Band, depending on how the wireless operations are deployed. In the companion *FNPRM*, we propose to adapt the ISIX Methodology to determine whether a wireless licensee can operate in a restricted area following the auction.<sup>82</sup>

24. Because new 600 MHz Band wireless operations will not be deployed until after the incentive auction, the ISIX Methodology and input values we adopt in this Order necessarily rely on a number of assumptions, all of which are described in the *ISIX PN* and the attached Technical Appendix.

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<sup>76</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6648, para. 174 ("The majority of UHF stations will be assigned to channels that are lower in the band than their original channels, because under the 600 MHz Band Plan the Commission will be seeking to repurpose UHF spectrum contiguously from channel 51 down, meaning that stations being reassigned to new channels within the UHF band generally will be assigned to channels lower in the band. Such stations are likely to experience *decreases* rather than increases in coverage lost to terrain within their contours due to the superior propagation characteristics of their lower frequencies.").

<sup>77</sup> See *supra*, note. [52] and accompanying text.

<sup>78</sup> We will use *TVStudy* to run the ISIX calculations during the incentive auction.

<sup>79</sup> We will address the specific uses to be made of the ISIX Methodology during the auction in detail in the forthcoming *Comment PN* on auction procedures. The "600 MHz Band" refers to the spectrum that will be repurposed for new, flexible uses through the incentive auction. The 600 MHz Band Plan the Commission adopted in the *Incentive Auction R&O* consists of paired uplink and downlink bands which will be offered in 5+5 megahertz blocks. The uplink band will begin at channel 51 (698 MHz) and expand downward, followed by a duplex gap and then the downlink band. See *Incentive Auction R&O*, 29 FCC Rcd 6575, para. 17.

<sup>80</sup> Threshold determinations for wireless license impairments will be addressed in the *Comment PN*.

<sup>81</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 86 n. 276.

<sup>82</sup> See generally *infra*, *FNPRM* at paras.68-73.

To the extent that we have changed any of the assumptions proposed in the *ISIX PN*, we explain the basis for doing so below. We also address below commenters' objections to certain aspects of the ISIX Methodology and input values.<sup>83</sup> The results of the ISIX Methodology and input values we adopt in this *Second Report & Order* may be used for several purposes during the incentive auction.<sup>84</sup> We will address these uses in the forthcoming *Comment PN* on auction procedures.<sup>85</sup> Importantly, we do not determine in this Order how the ISIX Methodology and input values will be applied following the incentive auction. In the companion *FNPRM*, we seek comment on how to apply the ISIX Methodology after the auction as 600 MHz Band wireless operations are deployed.<sup>86</sup>

25. As discussed in detail below, although the ISIX Methodology may be characterized as more complex than the distance-based approach advocated by some commenters, we conclude that the ISIX Methodology's ability to account for different inter-service interference scenarios, local terrain obstacles and other factors make it significantly more spectrally efficient than a distance-based approach, and these benefits outweigh the costs of greater complexity. Also, its granularity is better suited to the requirements of conducting the incentive auction than a distance-based approach. Accordingly, we adopt the ISIX Methodology.

### 1. Background

26. In the *Incentive Auction R&O*, we adopted a flexible band plan framework that accommodates market variation.<sup>87</sup> Market variation occurs where broadcast stations remain on spectrum that is repurposed for wireless broadband under the 600 MHz Band Plan.<sup>88</sup> We explained that accommodating market variation is necessary because the amount of spectrum recovered along the Canadian and Mexican borders and in some markets may vary from that recovered in most markets nationwide.<sup>89</sup> Accommodating market variation will allow us to avoid limiting the amount of spectrum repurposed across the nation to what is available in the most constrained market.<sup>90</sup>

<sup>83</sup> National Public Radio's Comments regarding interference between DTV Channel 6 and noncommercial educational ("NCE") FM radio are beyond the scope of the *ISIX PN*. See Comments of National Public Radio, Inc. (filed March 18, 2014).

<sup>84</sup> For example, to determine spectrum clearing targets, we anticipate that we will need to estimate the population affected by impairments to prospective 600 MHz Band license areas. See *Incentive Auction R&O*, 29 FCC Rcd at 6605-6, para. 84, 6620, para. 116. Information about impairments also will be necessary to determine what bidding category particular licenses fall within, and we anticipate providing information about impairments to forward auction bidders as appropriate during the bidding process. See *Incentive Auction R&O*, 29 FCC Rcd at 6775-6, para. 506.

<sup>85</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6574, para. 15.

<sup>86</sup> Despite Joint Broadcasters' claims, the *ISIX PN* clearly proposed that the ISIX Methodology would be used in determining "impairments" during the auction. *Office of Engineering and Technology Seeks to Supplement the Incentive Auction Proceeding Record Regarding Potential Interference Between Broadcast Television and Wireless Services*, Public Notice, 29 FCC Rcd 712, 715, 718, 724-25 (2014) ("*ISIX PN*"); see Joint Broadcasters *ISIX PN* Comments at 3-4, 8, 10, 11. To the extent Joint Broadcasters believe that the *ISIX PN* was unclear as to whether the ISIX Methodology would also be used to assess interference post-auction, this issue is moot in light of the *FNPRM* on this issue.

<sup>87</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6605, para. 82 (discussing how the 600 MHz Band Plan can accommodate market variation to avoid restricting the amount of repurposed spectrum that is available in most areas nationwide).

<sup>88</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6604-6607, paras. 81-87.

<sup>89</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6575, para. 17, n 29.

<sup>90</sup> See *id.* While we decided to accommodate market variation, we recognized the advantages to having a generally consistent band plan. See *id.*, 29 FCC Rcd 6605 at para. 83. We will decide how much market variation to

(continued....)

27. Broadcasters and several other industry participants raised concerns over the potential for inter-service interference created by market variation. This potential interference results because, in constrained markets where broadcast television stations<sup>91</sup> are assigned to channels within the 600 MHz Band, television services and wireless services will be operating in close geographic proximity on either the same or adjacent frequencies. Some commenters proposed fixed geographic separation distances to mitigate such potential interference.<sup>92</sup> We stated in the *Incentive Auction R&O* that we would establish at a future date a methodology to prevent inter-service interference.<sup>93</sup>

28. On January 29, 2014, the Commission's Office of Engineering and Technology (OET) released a Public Notice seeking comment on an alternative to the fixed separation distance methodology to address inter-service interference.<sup>94</sup> The ISIX Methodology is intended to accommodate market variation in a more spectrally efficient manner than fixed separation distances. The rationale underlying the proposed ISIX Methodology was that a fixed geographic separation distance approach would be spectrally inefficient because it would group together different inter-service interference scenarios (e.g., wireless base station to television receiver, television transmitter to wireless user equipment, etc.) and apply separation distances based on the worst case scenario, without considering factors such as technical characteristics (i.e. antenna height, power), terrain variability, and density of population.<sup>95</sup>

29. As discussed in the *ISIX PN*, the varying degrees of spectral overlap between broadcast television and wireless services will impact to different degrees the potential for harmful interference between the two services.<sup>96</sup> Under the 600 MHz Band Plan adopted in the *Incentive Auction R&O*, six megahertz broadcast television channels will be repurposed as five megahertz wireless blocks.<sup>97</sup> The difference in channel bandwidth (six vs. five megahertz) means that the wireless spectrum blocks will not perfectly align with the existing television channels and, where market variation exists, there will be varying degrees of spectral overlap between the channels. As the wireless spectrum block moves from complete overlap in frequency with a television channel to an edge-to-edge separation of five megahertz, the level of undesired signal that the victim receiver can tolerate without experiencing interference increases. The *ISIX PN* proposed to define "co-channel operations" as any spectral overlap between a wireless spectrum block and a television channel in one megahertz increments ranging from +5 (complete

(Continued from previous page)

accommodate under different spectrum recovery scenarios in the forthcoming *Comment PN* on final auction procedures. See *id.*, 29 FCC Rcd 6605 at para. 84.

<sup>91</sup> See 47 C.F.R. § 73.3700 (a)(1). The term "broadcast television station" or "television station" as used in this section and in the companion *FNPRM* is limited to full power television stations and Class A television stations that will remain on the air following the incentive auction. See *Incentive Auction R&O*, section III.B.3a.

<sup>92</sup> See Letter from Rick Kaplan, NAB to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268 (Jul. 10, 2013) (NAB July 10, 2013 ex parte) (arguing that geographic separation is the "only reliable method of interference protection [...] and that the distance separation requirements to avoid DTV to wireless interference will be much greater than the established distance requirements to avoid wireless to DTV interference."). *Id.* at 1; see also Qualcomm *Supplemental Band Plan PN* Comments at iii, 14. Qualcomm advocates separation distances between television and wireless user equipment of approximately 500 km or 310 miles, and 100 km for television to wireless base stations. See *id.* at 14.

<sup>93</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6605-4, para. 84.

<sup>94</sup> See generally *ISIX PN*, 29 FCC Rcd 712. On February 21, 2014, the Commission also hosted a LEARN Workshop to discuss the methodology described in the *ISIX PN*. See *Incentive Auction Task Force Announces Date for Workshops on Feasibility Checking and Inter-Service Interference*, Public Notice, 29 FCC Rcd 748 (Jan. 30, 2014).

<sup>95</sup> *ISIX PN*, 29 FCC Rcd at 715.

<sup>96</sup> *ISIX PN*, 29 FCC Rcd at 716.

<sup>97</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6593-4, at paras. 62-64.

overlap) to +1 megahertz, and “adjacent channel operations” as a wireless spectrum block and television channel that do not overlap but are separated by less than five megahertz (edge to edge separation of five megahertz or less).<sup>98</sup>

30. The *ISIX PN* outlined four scenarios of potential interference when broadcast television and wireless operations are co-channel or adjacent channel in nearby markets: (1) digital television (DTV) transmitter to wireless base station (Case 1); (2) DTV transmitter to wireless user equipment (Case 2); (3) wireless base station to DTV receiver (Case 3); and (4) wireless user equipment to DTV receiver (Case 4).<sup>99</sup> These scenarios are shown graphically on Figure 1 below:

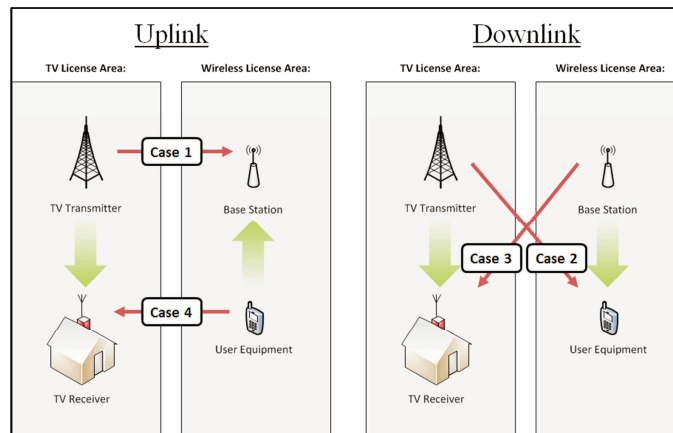


Figure 1: Four interference scenarios

31. The *ISIX PN* proposed to vary application of the *ISIX Methodology* and inputs depending on the interference scenario involved. It explained that the applicable interference scenarios would depend on whether broadcast television stations are assigned, in the event of market variation, in the uplink or downlink 600 MHz Band.<sup>100</sup> If television stations are assigned both in the downlink and uplink bands, all four interference scenarios would have to be evaluated. If television stations are placed in the uplink band, the relevant interference scenarios will be DTV transmitter to wireless base station (Case 1) and wireless user equipment to DTV receiver (Case 4). If television stations are placed in the downlink band, the relevant interference scenarios will be DTV transmitter to wireless user equipment (Case 2) and wireless base station to DTV receiver (Case 3). In the absence of an industry standard for predicting inter-service interference between broadcast and wireless services, the *ISIX PN* proposed to use the

<sup>98</sup> See *ISIX PN*, 29 FCC Rcd at 723-724. Co-channel operations are identified in the tables as +5MHz to +1 MHz and adjacent channel operations are identified as 0MHz to -5MHz.

<sup>99</sup> *ISIX PN*, 29 FCC Rcd at 713-715. The record reflects general accord over the four interference scenarios identified in the *ISIX PN*. See CTIA Comments at 5-6; Ericsson Comments at 2. Ericsson, however, states that interference cases 2 and 4 pose significantly lower risk to use of the 600 MHz Band for wireless broadband and may generally be ignored in deference to cases 3 and 1 respectively. See Ericsson Comments at 4. CTIA maintains that Case 1 is the “worst case” scenario requiring large exclusion zones, Case 2 is likely to require less separation distance than Case 1, Case 3 is more complicated, and Case 4 is most likely to be an adjacent channel interference problem. See CTIA Comments at 4-5.

<sup>100</sup> The 600 MHz Band Plan includes specific paired uplink and downlink bands. See *Incentive Auction R&O*, 29 FCC Rcd at 6587-90, paras. 51-57. The determination of where in the 600 MHz Band television stations will be placed in case of market variation will be addressed in the *Comment PN*.

Longley-Rice radio signal propagation model for certain interference scenarios and established planning factors and industry standards to define thresholds of coverage and interference.<sup>101</sup>

32. For Cases 1 and 2, the *ISIX PN* proposed to use the Longley-Rice model to predict the interference from a co-channel or adjacent-channel DTV transmitter to a wireless base station or wireless user equipment located within the wireless license area.<sup>102</sup> It proposed to assume values for DTV signal levels that are expected to occur statistically at no less than 50 percent of the locations 50 percent of the time (i.e. F(50,50)).<sup>103</sup> To determine wireless license area impairments (that is, areas where the wireless base station or user equipment is predicted to receive interference from a DTV transmitter), the wireless license area would be divided into cells using a two-kilometer grid.<sup>104</sup> The DTV field strength levels would be calculated at the population centroid<sup>105</sup> of each cell for each co-channel or adjacent-channel television station within approximately 500 kilometers.<sup>106</sup> The predicted DTV field strength at each cell would then be compared with the appropriate interference threshold.<sup>107</sup> Where the DTV field strength is above the interference threshold, the area of that cell would be deemed impaired. The *ISIX PN* proposed to consider “clutter loss” when predicting interference in Case 2.<sup>108</sup>

<sup>101</sup> See *ISIX PN*, 29 FCC Rcd at 727. The Longley-Rice model evaluates television coverage and interference. See NTIA Report 82-100, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode*, authors G.A. Hufford, A.G. Longley and W.A. Kissick, U.S. Department of Commerce, April 1982. Although the *ISIX PN* described a methodology and input values to predict interference from television to wireless services and vice versa, it did not propose rules limiting interference between these services. *ISIX PN*, 29 FCC Rcd at 718. Rules limiting harmful interference to television from wireless services are proposed in the companion *FNPRM infra*.

<sup>102</sup> *ISIX PN*, 29 FCC Rcd at 717; see also *id.* at 727. The only proposed differences in the treatment of Case 1 and Case 2 are the values of the receiver height (30 meters and 1.5 meters respectively), antenna gain (13.8dBd and -2.2 dBd), line loss (1dB and 0dB), and threshold sensitivity (-101.5dBm and -100 dBm), as well as the proposal to consider clutter loss for Case 2.

<sup>103</sup> *ISIX PN*, 29 FCC Rcd. at 717.

<sup>104</sup> *ISIX PN*, 29 FCC Rcd. at 724. See OET Bulletin No. 69 at 11 (calling for division of a television station’s service area into two-kilometer grid cells to predict interference between television stations).

<sup>105</sup> The population centroid is the fixed point in each cell of the grid based on the distribution of population in that cell, where field strength predictions are evaluated.

<sup>106</sup> Calculation distances from the DTV facility to the grid point would be set for a 0 dBμV/m F(50,10) contour at a minimum height above average terrain (HAAT) of 50 meters. This generally equates to a distance of about 500 kilometers but varies based on terrain and DTV facility parameters.

<sup>107</sup> The *ISIX PN* proposed to apply the field strength thresholds listed in Table 4 of the *ISIX PN*. Those thresholds, repeated below, are based on technical assumptions regarding the wireless receivers (both base stations and user equipment) that appear respectively in Tables 5 and 6 in the *ISIX PN*.

Spectral Overlap (MHz)	5	4	3	2	1	0	-1	-2	-3	-4	-5
DTV Field Strength into Wireless Uplink (dBμV/m)	17.3	18.2	19.5	21.2	24.0	34.4	61.4	62.5	63.7	65.5	68.6
DTV Field Strength into Wireless Downlink (dBμV/m)	33.8	34.7	36.0	37.6	40.4	50.7	65.8	66.6	67.6	68.9	70.8

<sup>108</sup> Clutter loss refers to predicted losses in signal strength due to local obstacles such as foliage or buildings; losses associated with the category of clutter at a receiver are added to predicted propagation loss to arrive at total path loss between a transmitter and receiver. The proposed clutter loss values were listed in Table 15 of the *ISIX PN*. See *ISIX PN*, 29 FCC Rcd at 737.

33. For Case 3, the *ISIX PN* also proposed to use the Longley-Rice model to predict interference from a wireless base station to a DTV receiver.<sup>109</sup> The *ISIX PN* proposed to divide the area within a television station's contour into cells using a two-kilometer grid, and to calculate undesired wireless base station field strength levels at each cell or grid point to determine areas of possible interference.<sup>110</sup> Because 600 MHz Band wireless base stations will not be deployed until after the incentive auction, for purposes of applying the proposed ISIX Methodology during the auction uniformly spaced sample locations, spaced every ten kilometers within the boundaries of every wireless license area that is within 500 kilometers of the television station would be evaluated.<sup>111</sup> A hypothetical base station with non-directional transmitting antennas 30 meters height above average terrain (HAAT) and 720 watts Effective Radiated Power (ERP) would be placed at each location and a Desired/Undesired (D/U) ratio would be predicted for each grid point.<sup>112</sup> That D/U ratio would be compared with the appropriate interference threshold.<sup>113</sup> If the threshold were exceeded, then the entire area within the county containing the hypothetical base station would be predicted to cause interference to the television station. The *ISIX PN* proposed specific D/U ratios depending on the amount of spectral overlap between the wireless spectrum block and the television channel.<sup>114</sup> It also proposed to apply "clutter loss" to account for local environmental characteristics in the prediction of interference.<sup>115</sup> In addition, the *ISIX PN* proposed to use the predicted field strength available at any locations where the Longley-Rice model returns an "error code 3" message.<sup>116</sup>

34. One of the proposed ISIX Methodology's key assumptions for predicting interference to television stations is that the Advanced Television Systems Committee (ATSC) DTV technology and Long Term Evolution (LTE) wireless transmission technology (which is expected to be used by 600 MHz Band wireless licensees) have a similar interference potential because both produce signals with noise-like emission characteristics.<sup>117</sup> If so, the interference potential to television stations from ATSC DTV and wireless services would also be similar. Based on this assumption, the *ISIX PN* proposed to apply the existing D/U ratios for television-to-television interference set forth in the Commission's rules for Case 3,

<sup>109</sup> *ISIX PN*, 29 FCC Rcd at 725.

<sup>110</sup> *ISIX PN*, 29 FCC Rcd. at 725. See OET Bulletin No. 69 at 11 (calling for division of a television station's service area or contour into ten-kilometer grid cells to predict interference between DTV stations). The term "contour" refers to either the "noise-limited contour" for full power television stations or "protected contour" for Class A television stations. See 47 C.F.R. §§ 73.622(e), 73.6010.

<sup>111</sup> *ISIX PN*, 29 FCC Rcd at 725, 733, Table 10.

<sup>112</sup> The desired to undesired ratio (D/U) is a measure of how much the electric field strength of the desired signal exceeds the field strength of the undesired signal at the measurement point. When the desired signal is very strong in relation to the interfering signal, the D/U ratio is large. As the field strength of the interfering signal approaches the field strength of the desired signal, the D/U ratio decreases and interference is more likely to occur. The D/U threshold sets the minimum D/U ratio that can be tolerated by the desired receiver before interference is assumed to occur.

<sup>113</sup> *ISIX PN*, 29 FCC Rcd at 732, Table 8.

<sup>114</sup> *ISIX PN*, 29 FCC Rcd at 732, Table 8 (D/U ratios above the proposed threshold in the Table reflect no interference to television, while D/U ratios below the proposed threshold reflect interference to television).

<sup>115</sup> *ISIX PN*, 29 FCC Rcd at 735.

<sup>116</sup> *ISIX PN*, 29 FCC Rcd at 729. Such warning messages or flags (code 3) are generated when the obstacle nearest to either the transmit or receive location along the propagation path is significantly above or below the height of the transmit or receive antenna. Specifically, they are generated when the absolute value of the horizontal elevation angle to the nearest terrain obstacle is greater than 0.2 radians, or approximately 11.5 degrees. See NTIA Institute for Telecommunication Sciences (ITS), Description of the ITM/Longley-Rice Model, available at: <http://www.its.bldrdoc.gov/media/35869/itm.pdf>, sections 2, 5, 7, and 8.

<sup>117</sup> *ISIX PN*, 29 FCC Rcd at 716.

with adjustments for varying degrees of spectral overlap.<sup>118</sup> Some commenters argued that LTE signals could have different characteristics requiring different D/U ratios.<sup>119</sup> In response to these concerns, OET conducted measurements of the susceptibility of four DTV receivers to interference from LTE signals.<sup>120</sup> In addition, Consumer Electronics Association (CEA) submitted a report with measurements of the susceptibility of six newer DTV receivers and two older DTV receivers to interference in the presence of an LTE signal that showed similar results.<sup>121</sup> On June 20, 2014, OET released a Public Notice seeking comment on the results of these two studies.<sup>122</sup> The *Measurements PN* requested comment on whether the OET measurements, in conjunction with CEA's measurements, support the D/U ratios, Off Frequency Rejection (OFR),<sup>123</sup> and power adjustments proposed in Tables 8, 9 and 10 of the *ISIX PN*.<sup>124</sup>

35. For Case 4, the *ISIX PN* noted that because wireless base stations require a relatively large separation distance from the co-channel DTV transmitters, there is no significant risk of co-channel interference to DTV reception from wireless user equipment.<sup>125</sup> However, that may not be the case with adjacent channel interference.<sup>126</sup> The *ISIX PN* further noted that the broadcast industry suggested a fixed geographic separation distance of five kilometers between co-channel wireless user equipment and a DTV receiver and sought comment.<sup>127</sup>

## 2. Discussion

### a. Digital Television to Wireless Interference (Cases 1 and 2)

36. We adopt the *ISIX* Methodology and input values as proposed in the *ISIX PN* for use during the incentive auction to predict interference from DTV transmitters to wireless base stations (Case 1) and wireless user equipment (Case 2), except that we will not consider clutter loss for Case 2.<sup>128</sup> While wireless commenters support the proposed consideration of clutter loss for Case 2, we determine that considering clutter loss would not improve the accuracy of the *ISIX* Methodology.<sup>129</sup> The resolution of the clutter database is 30 meters and, therefore, every grid cell would have more than 4,000 associated

<sup>118</sup> *ISIX PN*, 29 FCC Rcd at 716. The DTV-to-DTV interference protection ratios are set forth in 47 C.F.R. § 73.623(c).

<sup>119</sup> See, e.g., SBE Comments at 6, Joint Broadcasters Comments at 18-24.

<sup>120</sup> See *Office of Engineering and Technology Seeks Comment on Measurements of LTE into DTV Interference*, Public Notice, GN Docket No. 12-268, ET Docket No. 14-14, DA 14-852 (Jun. 20, 2014) ("Measurements PN").

<sup>121</sup> Letter from Julie M. Kearney, CEA to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268, ET Docket No. 14-14 (filed May 22, 2014) ("CEA Measurements Report"). CEA tested television receivers from the model years 2006, 2012, and 2013.

<sup>122</sup> See generally *Measurements PN*, DA 14-852.

<sup>123</sup> Off Frequency Rejection (OFR) is a reduction in a receiver's susceptibility to interference that occurs when an interfering signal does not fully occupy the band to which the receiver is tuned. OFR is a result of the rolloff of the transmitter emission mask and the receiver selectivity filters attenuating out-of-band emissions.

<sup>124</sup> See *Measurements PN* at 2.

<sup>125</sup> See *ISIX PN*, 29 FCC Rcd at 714-715.

<sup>126</sup> See *ISIX PN*, 29 FCC Rcd at 715.

<sup>127</sup> See *ISIX PN*, 29 FCC Rcd at 727. See July 10, 2013 NAB Ex Parte; Joint Broadcasters Comments at 39.

<sup>128</sup> The *ISIX PN* did not propose to consider clutter loss for Case 1.

<sup>129</sup> See Transmit Comments at 3, 4G Americas Comments at 9, CTIA Comments at 7.

clutter values.<sup>130</sup> The one clutter value selected in each cell would not be representative of the entire cell and thus would fail to provide for an accurate assessment of the interference environment.<sup>131</sup>

37. We will use the proposed F(50,50) statistical measure to predict the strength of an interfering television signal within the wireless license area for Cases 1 and 2 rather than the F(50,10) measure advocated by broadcasters. The F(50,50) measure assumes that the DTV signal will be strong enough to interfere with the wireless base station or wireless user equipment in 50 percent of the locations within the wireless license area 50 percent of the time; the F(50,10) measure would assume that the interfering signal will be strong enough to interfere in 50 percent of the locations 10 percent of the time. The Joint Broadcasters support use of the F(50,10) measure as more conservative and more consistent with Commission practice.<sup>132</sup> We conclude that the F(50,50) measure is more appropriate for use in predicting interference from DTV signals to wireless operations during the auction. First, the F(50,50) measure will not risk harming broadcasters because it will be applied only during the incentive auction and only to predict interference to wireless operations from television stations for auction-related purposes, not to protect television signals. Second, the majority of wireless providers, who have the greatest stake in the accuracy of predicted inter-service interference to wireless operations, support use of the F(50,50) measure, supporting the conclusion that it will provide a reasonably accurate assessment of such interference.<sup>133</sup> Third, use of the F(50,50) measure is appropriate in this context because various techniques are available to wireless operators to avoid harmful interference to wireless base stations that are not available to television stations or viewers.<sup>134</sup> Accordingly, we disagree with the Joint Broadcasters that use of the F(50,50) measure is inconsistent with Commission practice in predicting interference between DTV stations. Under the circumstances, we conclude that use of the more conservative F(50,10) measure is neither necessary nor consistent with our goals for the incentive auction.

38. We decline to adopt Qualcomm's suggested parameters for wireless user equipment in lieu of the parameters proposed in the *ISIX PN*.<sup>135</sup> While the antenna gain value suggested by Qualcomm

<sup>130</sup> The 2006 National Land Clutter Database (NLCD) is available from the Multi-Resolution Land Characteristics Consortium (MRLC) at <http://www.mrlc.gov/nlcd2006.php>

<sup>131</sup> See *ISIX PN*, 29 FCC Rcd at 736-737. The clutter value to be selected would correspond to the clutter value at the population centroid or geometric center of the grid cell.

<sup>132</sup> See Comments of the National Association of Broadcasters, ABC Television Affiliates Association, FBC Television Affiliates Association, CBS Television Network Affiliates Association, NBC Television Affiliates, the Association of Public Television Stations, the Corporation for Public Broadcasting, and the Public Broadcasting Service (collectively the "Joint Broadcasters"), GN Docket No. 12-268, ET Docket No. 14-14, at 29-30 (filed Mar. 18, 2014) (arguing that any inter-service interference methodology should be based on "long-standing use of FCC's F(50,10) prediction statistics"); SBE Comments at 5-6 (arguing that the FCC should use a conservative approach to minimize the likelihood of interference and that a F(50,10) would be more appropriate for predicting interference from DTV into wireless services). The F(50,10) statistical measure is more conservative because 90 percent of the time the strength of the interfering signal will be less than predicted.

<sup>133</sup> See Letter from AJ Burton, Counsel to T-Mobile USA, Inc. to Marlene H. Dortch, Secretary, FCC, ET Docket No. 14-14, GN Docket No. 12-268 (filed Jun. 13, 2014) ("T-Mobile Ex Parte"); see also Letter from Brian J. Benison, AT&T Services, Leona Hochstein, Verizon, Chris Wiczorek, T-Mobile to Marlene H. Dortch, FCC, GN Docket 12-268 (filed Jun. 13, 2014) ("Wireless Joint Letter"). But see Sprint Comments at 8, 9 n. 10 (arguing that wireless operators set high standards for network reliability, the F(50,10) measure would provide operators with a better understanding of potential impairment, and the F(50,50) measure may chill forward auction participation).

<sup>134</sup> See T-Mobile Ex Parte at 1-2 ("unlike noise-limited broadcast television, LTE systems are interference-limited"); see also 4G Americas Comments at 4 ("OET correctly notes that advances in mobile technology, such as Multiple-Input Multiple-Output (MIMO) antenna technology and resource block provisioning, will enable mobile operators to mitigate potential interference).

<sup>135</sup> Letter from Dean R. Brenner, Qualcomm, to Marlene Dortch, FCC, GN Docket No. 12-268, ET Docket No. 14-14 (filed Mar. 18, 2014) ("Qualcomm Ex Parte"). Qualcomm proposed an antenna gain of -6 dBi and a noise figure of 9 dB, instead of 0 dBi and 7.5 dB, respectively, as proposed in the *ISIX PN*. See *ISIX PN* at 731, Table 6.

may reflect today's smartphones, we expect other wireless devices to be used in the 600 MHz Band, like tablets or personal Wi-Fi hotspots, that could have either a higher antenna gain or a better antenna efficiency and thus be more susceptible to harmful interference. We find it appropriate to account for the types of devices that will most likely be used in the 600 MHz Band. Qualcomm also claims that the proposed parameter value for noise figure should be increased from 7.5 dB to 9 dB.<sup>136</sup> However, the proposed value accounts for factors in addition to receiver noise that should be considered when calculating an effective noise figure.<sup>137</sup> Therefore, we decline to adopt Qualcomm's suggested values for wireless user equipment.

39. We decline to adopt the Joint Broadcasters' suggested fixed distance-based approach for Cases 1 and 2.<sup>138</sup> The Joint Broadcasters' approach for Case 1 (television transmitter to wireless base station) would create unreasonably large zones where wireless operations would be deemed "impaired" by interference because their approach does not account for specific terrain obstacles that mitigate the potential for interference from television stations to wireless operations.<sup>139</sup> As a result, it would significantly increase the predicted impairments to wireless license areas and exclude from the forward auction spectrum that could otherwise be offered for wireless services if impairments were assessed more accurately. For example, under the Joint Broadcasters' proposal, a television station in Los Angeles could be predicted to interfere with wireless operations in Las Vegas. In contrast, the ISIX Methodology would evaluate the effect of terrain on the propagation of the interfering television signal. As a result, areas shielded by terrain, such as mountains, would not be identified as impaired by potential interference that is not likely to occur in those locations. Applying the ISIX Methodology in the example above, wireless operations in Las Vegas would not be considered impaired because of the shielding provided by the San Gabriel and San Bernardino mountain ranges. As a result, a wireless license in Las Vegas would be deemed unimpaired because of this terrain shielding and can therefore be auctioned even when there is a television station co-channel or adjacent channel in Los Angeles. The approach we adopt will assess the interference environment and wireless license area impairments significantly more accurately in Case 1 than the Joint Broadcasters' suggested approach of a generic separation distance.

40. For Case 2 (television transmitter to wireless user equipment), the Joint Broadcasters' proposed five-kilometer separation distance would not adequately reflect the potential impairment to a wireless license area. The Joint Broadcasters conflate their proposed separation distances for Case 1 with those for Case 2 and assume that the Case 1 distances will preclude wireless user equipment from operating near a television station.<sup>140</sup> As stated above, however, the Case 1 interference scenario will only

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<sup>136</sup> A receiver's "noise figure" is an expression of the level of radiofrequency noise energy that is generated within the device itself as a result of its design and operation.

<sup>137</sup> The effective noise figure of 7.5 dB proposed in the *ISIX PN* reflects the receiver noise figure of 9 dB plus an assumed minimum signal-to-noise (SNR) ratio of -1 dB plus an implementation margin (IM) of 2.5 dB. See *ISIX PN*, 29 FCC Rcd at 731, Table 6; see also *LTE for UMTS: Evolution to LTE-Advanced*, Holma, H. and Toskala, A., Section 14.8, Wiley, 2011.

<sup>138</sup> For Case 1, Joint Broadcasters' approach would calculate contours for individual television stations using the same methodology used to compute DTV noise-limited service contours, the television station's transmitter operating parameters, the FCC F(50,10) values, and the field strength limits specified in Table 4 of the *ISIX PN*. See Joint Broadcasters Comments at 38. Joint Broadcasters also adjusted the proposed interference thresholds for Case 1 by 3.5 dB to reflect the maximum allowable wireless base station antenna height of 305 meters rather than 30 meters assumed in the *ISIX PN*. *Id.* The contour distances would then be used to determine whether wireless operation in a spectrum block in a service area is impaired and the percentage and location of any interference contour overlap in that area. *Id.*

<sup>139</sup> Joint Broadcasters' approach is based on FCC curves as those appear in 47 C.F.R. § 73.699. These curves only consider terrain that is between two and ten miles from the DTV transmitter site.

<sup>140</sup> For Case 2, the Joint Broadcasters request that co-channel wireless handset operations be prohibited within five kilometers of the noise-limited service contour of a co-channel DTV station and that adjacent-channel wireless

(continued....)

occur if a television station is placed in the 600 MHz uplink spectrum, while Case 2 will only occur if a television station is placed in the 600 MHz downlink spectrum.<sup>141</sup> In addition, wireless user equipment is more sensitive than television receivers, and the high power and height of typical DTV transmitters require separation distances that can be much greater than five kilometers. However, adopting a generic distance-based separation to provide additional protection for wireless user equipment would raise the same concerns discussed above with regard to Case 1. Therefore, our approach of predicting the specific locations (on a two-kilometer grid) where the interfering DTV field strength exceeds the thresholds will provide wireless providers with more accurate information as to wireless license area impairments.

41. The Joint Broadcasters also argue that a fixed distance-based approach – for Case 1 and Case 2 – would be “far easier to implement and will not sacrifice meaningful spectral efficiency.”<sup>142</sup> Although we recognize that the ISIX Methodology we adopt may be more complex than a fixed distance-based approach, we conclude that the added complexity of our approach is justified by its benefits.<sup>143</sup> The ISIX Methodology’s granularity, tailored approach to different interference scenarios, and ability to account for factors that will mitigate interference in individual cases will generally lead to more accurate interference predictions. This is critical to meeting our goals for the incentive auction because overestimating the extent of wireless license area impairments may limit our ability to repurpose spectrum for new uses through the auction. Moreover, more accurate predictions and more granular data will allow for more informed decisions, both for the Commission in determining whether to auction certain licenses and for auction participants in making bidding decisions. We also note that, contrary to the Joint Broadcasters, most commenters support the ISIX Methodology.<sup>144</sup> For Cases 1 and 2, we therefore conclude that the benefits of the ISIX Methodology’s increased accuracy over an oversimplified fixed distance-based approach outweigh its costs in terms of additional complexity.

(Continued from previous page)

handset operations be prohibited within the contour of an adjacent-channel DTV station. *See* Joint Broadcasters Comments at 38-39.

<sup>141</sup> *See supra*, para. 31. It is possible for a 600 MHz license to be impaired by both a Case 1 interference scenario (*i.e.*, a DTV station in license’s uplink frequencies interfering with wireless base stations) and a Case 2 scenario (*i.e.*, a different DTV station in the license’s downlink frequencies interfering with wireless user equipment).

<sup>142</sup> Joint Broadcasters Comments at 31; *See* SBE Comments at 2 (arguing that the Commission should use fixed geographic separation distances “precisely *because* they are conservative, and create the best opportunity to avoid interference *ex ante*”).

<sup>143</sup> For the reasons below, we find in Case 4 that a simpler, fixed-distance approach is warranted. *See infra*, paras. 56-58. We note that the Joint Broadcasters’ emphasis on the ISIX Methodology’s computational complexity, *see* Joint Broadcasters Comments at 34-35, is unpersuasive: the required computations mostly will be completed prior to the incentive auction, and will not impact the Commission’s ability to conduct the incentive auction bidding process with the speed necessary for the auction’s success. *See supra*, para 16.

<sup>144</sup> *See e.g.*, 4G Americas at 5-8 (ISIX Methodology is “a fundamentally sound approach to predicting and preventing the possibility of interference between LTE broadband service and ATSC broadcast television service”); CTIA at 3-7 (“the overall framework presented in the Public Notice is fundamentally correct and appears to have the building blocks needed to model this intricate interference environment.”); Ericsson at 2-6 (“generally accepts that the proposed methodology in the Public Notice can provide reasonable guidance on minimum separation distances between DTV operation and mobile broadband frequencies”); Sprint at 3-10 (supports ISIX Methodology with the following changes for predicting interference to wireless services: (1) “the Commission should additionally provide information on the number of grid cells that were analyzed within the wireless market and a percentage indicating how many of those grid cells were considered impaired based on modeling”; (2) calculate field strength for television to wireless interference using F(50, 10) values; and (3) auction spectrum in areas where D/U ratios are minimally exceeded); Transmit at 3 (agrees that a computer modeling approach will “provide better accuracy and result in a better approach” than a fixed-distance approach but cautions that “some consideration should be given to the optimum grid size for the calculations to balance the likely impact and ease of calculation”).

**b. Wireless to Digital Television Interference**

**(i) Case 3: Wireless Base Station to Digital Television Receiver**

42. We adopt the ISIX Methodology and input values as proposed in the *ISIX PN* for use during the incentive auction to predict interference from wireless base stations to DTV receivers (Case 3), except that (1) we adopt slightly higher D/U ratios (by 1 dB) for co-channel operations based on the measurements conducted by the staff and CEA, and (2) we will not consider clutter loss.

43. *D/U ratios.* As stated above, the *ISIX PN* was premised on the assumption that ATSC DTV and LTE signals are sufficiently similar that the D/U ratios in our rules for television-to-television interference can be used in predicting interference from wireless base stations to television receivers.<sup>145</sup> In response to concerns raised by some commenters,<sup>146</sup> OET measured the susceptibility of a number of DTV receivers to interference from LTE signals, and CEA conducted additional measurements with six different DTV receivers.<sup>147</sup> We conclude that the record supports the D/U ratios proposed in the *ISIX PN* for adjacent channel interference based on the measurements conducted by staff and CEA.<sup>148</sup> However, based on the measurement data, LTE signals create slightly more co-channel interference to DTV reception than other DTV signals.<sup>149</sup> We conclude that the D/U ratios proposed in the *ISIX PN* for co-channel interference should be increased by 1 dB from 15 dB to 16 dB in light of this data.<sup>150</sup> Therefore, we adopt the following D/U ratios for different degrees of spectral overlap in Case 3. This adjustment will result in a more accurate determination of impairments to co-channel wireless operations to any broadcast television stations that are assigned to the downlink 600 MHz Band spectrum as a result of market variation. The D/U ratios are accordingly adjusted as shown in Table 1 below.

Spectral Overlap (MHz)	5	4	3	2	1	0	-1 to -5 <sup>151</sup>
Downlink into DTV D/U Required (dB)	16.0 + $\alpha$	15.1 + $\alpha$	13.8 + $\alpha$	12.1 + $\alpha$	9.3 + $\alpha$	-2.0 + $\alpha$	-18 + $\alpha$

Table 1. D/U ratio limits for wireless interference to DTV.

44. While one receiver OET measured was predicted to receive interference at the D/U ratios we adopt in this Order,<sup>152</sup> we conclude that this result does not undermine our decision. This receiver is a

<sup>145</sup> See *supra*, para. 34; *ISIX PN*, 29 FCC Rcd at 716. As explained in the *Incentive Auction R&O*, we assume LTE for wireless operations as the “typical case . . . because commenters have suggested it is a likely technology to be used in this band.” *Incentive Auction R&O*, 29 FCC Rcd at 6589-90, para. 55; but see Comments of Cohen, Dippell, and Everist, P.C. (filed March 18, 2014).

<sup>146</sup> See SBE Comments at 6; Joint Broadcasters at 18-24.

<sup>147</sup> See *generally Measurements PN*, DA 14-852.

<sup>148</sup> The thresholds we adopt for adjacent channel operations will provide protection that is several dB or more greater than that proposed in the *ISIX PN*, where spectral overlap is less or equal to 0 MHz. See *infra*, para. 47.

<sup>149</sup> See *Measurements PN* at X. NAB argues that its data indicates that the D/U values for LTE-to-DTV interference for a 5 MHz LTE signal was 2.7 and 0.6 dB worse than that measured for DTV-to-DTV interference). See NAB *Measurements PN* Comments at 15. The 2.7 value that NAB refers to reflects measurements on the digital-to-analog converter box discussed below. The 0.6 value for the newest receiver model tested is consistent with CEA data reflecting that a median 0.9 dB increased D/U ratio is required to prevent LTE interference to newer DTV receiver models. See CEA Measurements Reports, Table G-2. The D/U ratios we adopt in this Order will effectively address the slightly increased LTE signal interference risk reflected in the data.

<sup>150</sup> See OET-69, Table 5A; see also App. A, Technical Appendix, at para. 22, Table 7.

<sup>151</sup> See App. A, Technical Appendix at para. 30, n. 28, Table 12.

<sup>152</sup> See *Measurements PN* at 8, Table 1 (references to Receiver 1 (Rx1)).

digital-to-analog converter box. While we recognize that such converter boxes remain in use and are still commercially available, the analog-only television receivers they are used with are reaching the end of their life cycles.<sup>153</sup> Television receivers with digital tuners have no need of such converter boxes, and new television receivers have been required to include digital tuners since July 2004.<sup>154</sup> Thus, most television receivers purchased since then have no need for a converter box. We decline to adjust the D/U ratios we adopt based on the susceptibility to LTE signal interference of obsolete analog-to-digital converter boxes, the vast majority of which will no longer be in service during and after the 39-month Post Auction Transition Period<sup>155</sup>

45. Although broadcasters argue for more measurements, no commenter disagrees that DTV and LTE signals behave similarly because both have noise-like emission characteristics. The measurement data from OET and CEA encompasses most new models of DTV receivers,<sup>156</sup> as well as a representative sample of older models.<sup>157</sup> With the exception of the one digital-to-analog converter box that is no longer likely to be in use within a few years, as discussed above, none of the DTV receivers

<sup>153</sup> Analog-only television receivers have not been shipped in or imported into the United States since 2007. See *Requirements for Digital Television Receiving Capability*, ET Docket No. 05-24, Second Report and Order, 20 FCC Rcd 18607 (2005) (requiring TV receivers to include digital reception capacity by March 1, 2006 for TV receivers with screen sizes 25-36 inches and by March 1, 2007 for TV receivers with screen sizes 13-24 inches).

<sup>154</sup> In 2002, the Commission established a phased-in schedule for the requirement that all television receivers shipped in interstate commerce or imported into the United States be equipped with a digital tuner. See *Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television*, MM Docket No. 00-39, Second Report and Order and Second Memorandum Opinion and Order, 17 FCC Rcd 15978 (2002), *aff'd*, *Consumer Electronics Ass'n v. FCC*, 347 F.3d 291 (D.C. Cir. 2003). Under that schedule, no television receiver could be shipped in interstate commerce or imported into the United States without a digital tuner after July 2007.

<sup>155</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6796, para. 559 (defining the "Post-Auction Transition Period" as the 39-month transition period for broadcasters that are assigned new channels in the repacking process and winning UHF-to-VHF and high-VHF-to-low-VHF bidders to relocate to their new channels. The Post-Auction Transition Period will include (1) the three-month period beginning upon the release of the Channel Reassignment PN, during which broadcasters will complete and file their construction permit applications, followed by (2) a 36-month period consisting of varied construction deadline). See *id.*

<sup>156</sup> CEA notes that the newer models of receivers tested represented an estimated 85 percent of DTV receiver shipments in the U.S. in the period 2012-2013. *CEA Measurements Report* at 1. CEA tested DTV receivers from model years 2006, 2012 and 2013. We also note that we have no reason, and NAB identifies none, to believe that there would be any significant difference in the performance of 2007-2011 models from the 2006 and 2012-2013 models tested. See NAB *Measurements PN* Comments at 10. Through 2007, comprehensive testing conducted by the FCC Laboratory identified that all receivers included in its tests were single-conversion tuners with an intermediate frequency (IF) of 44 MHz. See Stephen R. Martin, "Interference Rejection Thresholds of Consumer Digital Television Receivers Available in 2005 and 2006," FCC/OET Report 07-TR-1003, March 30, 2007. The concept of "low-IF" tuners, with intermediate frequencies much lower than conventional receivers, was introduced in 2008, and tuners of this type were made available in the marketplace not long afterward. See Lervstaveesin, S., *et al.*, *A 48-860 MHz CMOS Low-IF Direct-Conversion DTV Tuner*, IEEE Journal of Solid-State Circuits, 43(9):2013-2024, September 2008. The more recent testing conducted by both OET and CEA includes these two classes of receivers – those with conventional IF frequencies, representing receivers commercially available until 2009, and those with newer "low-IF" tuners, representing a significant percentage of commercially available receivers along with conventional receivers still in the marketplace 2009 and after.

<sup>157</sup> The set top box examined in the OET study performed closest to median (*i.e.*, the most typical) across all receiver performance tests conducted in OET's previous measurement reports. See Stephen R. Martin, "Interference Rejection Thresholds of Consumer Digital Television Receivers Available in 2005 and 2006," FCC/OET Report 07-TR-1003, March 30, 2007. See also "Tests of ATSC 8-VSB Reception Performance of Consumer Digital Television Receivers Available in 2005," FCC/OET Report TR-05-1017 November 2, 2005. The median performance of the tested set top box across all previous testing lends credence to reliance on its performance as a measure of the central tendency of population.

OET tested was susceptible to LTE signal interference at the D/U ratios we adopt in this Order. Testing additional receivers under different conditions, as broadcasters advocate,<sup>158</sup> would delay this proceeding, and therefore the auction, without contributing meaningfully to the data in the record. Accordingly, we conclude that the D/U ratios we adopt are sufficient to protect DTV receivers from LTE signal interference.

46. We reject claims that the measurement data in the record is not reliable because it does not consider factors such as multiple LTE interferers, third-order intermodulation (IM3) or taboo interference, and splatter.<sup>159</sup> The Commission's rules governing DTV-to-DTV interference do not address these factors, yet there is no evidence that the rules fail to adequately protect DTV signals as a result. Likewise, OET-69 does not consider taboo interference in its calculations but only considers the interference protections provided in the rules.<sup>160</sup> Equipment manufacturers are aware of these factors and are expected to consider them when designing their receiver products.<sup>161</sup> Because the Commission's existing rules do not include provisions to protect DTV signals from the effects of multiple DTV interferers, IM3 or splatter, we decline to account for such factors in the D/U ratios we adopt for Case 3, and we conclude that the measurement data in the record is reliable despite the lack of information regarding these factors.<sup>162</sup> Further, we disagree with NAB's assertions that in developing the DTV Table

<sup>158</sup> See NAB *Measurements PN* Comments at 8 (contending that the number of DTV receivers examined was too small); see also ATBA *Measurements PN* Comments at 5.

<sup>159</sup> NAB *Measurements PN* Comments at 3. There are certain combinations of channels in the UHF band that may interfere with television reception, primarily as a result of receiver performance. Taboo channels (*e.g.*, channels  $\pm 2$ , 3, 4, 5, 7, 8, 14, and 15 in relation to the desired channel) exist as a result of these performance issues, where  $\pm 2$ , 3, 4, 5, arise principally due to poor receiver selectivity and third-order intermodulation products generated within the receiver under certain conditions, and  $\pm 7$ , 8, 14, and 15 arise due to interactions with the local oscillator frequency of the receiver, which has characteristically been set at 44 MHz. Technical solutions exist to improve the performance of TV receivers on these taboo channels; for instance: tracking filters could improve selectivity, double conversion tuners could improve intermodulation, and low-IF tuners could improve resiliency against interactions at 44 MHz from the desired channel. Some receivers made available more recently have already been designed this way. See *e.g.*, Stephen R. Martin, *DTV Converter Box Test Program—Results and Lessons Learned*, FCC/OET Report 09-TR-1003, October 9, 2009, Chapter 4. See also Lerstaveesin, S., *et. al.*, *A 48–860 MHz CMOS Low-IF Direct-Conversion DTV Tuner*, *IEEE Journal of Solid-State Circuits*, 43(9):2013-2024, September 2008. “Splatter” refers to noise in the desired channel caused by adjacent channel interference or third order intermodulation products. Splatter arises principally due to adjacent-channel leakage into the desired channel from the sideband attenuation performance of the emission filter and third-order intermodulation products generated within the transmitter. See, *e.g.*, Sgrignoli, G., *DTV Repeater Emission Mask Analysis*, *IEEE Transactions on Broadcasting*, 49(1):32-80, March 2003.

<sup>160</sup> See OET-69 at 8. The Commission's rules do contain one reference to taboo interference in the table showing DTV-to-analog protection, but that table is no longer applicable following the completion of the DTV transition for full power stations in 2007. See 47 C.F.R. § 73.623(c)(2).

<sup>161</sup> We note that the ATSC DTV receiver performance guidelines include performance standards to address the presence of these conditions. See ATSC Recommended Practice A/74: Receiver Performance Guidelines, section 5.4.3, Taboo Channel Rejection, 7 Apr. 2010, available at [http://www.atsc.org/cms/standards/a\\_74-2010.pdf](http://www.atsc.org/cms/standards/a_74-2010.pdf) (last visited May 1, 2014).

<sup>162</sup> Sinclair and Linley Gumm and Charles Rhodes argue that the 600 MHz Band's broad LTE operating bandwidths (up to 20 MHz) and the potential for adjacent broadcast services on 6 MHz channels necessitate addressing taboo interference in the ISIX Methodology. See Comments of Sinclair Broadcast Group, Inc., ET Docket No. 14-14, GN Docket No. 12-268, at 6-7 (filed Mar. 18, 2014), Comments of Linley Gumm and Charles Rhodes, ET Docket No. 14-14, GN Docket No. 12-268 (filed Feb. 24, 2014). However, there are situations under the current rules where multiple DTV signals occupy channels on broad bandwidths that are similar to the situation that concern Sinclair and Mr. Gumm and Mr. Rhodes and we have no reports of verified interference from multiple interferers, IM3 or splatter. While it is conceivable that taboo-like signal patterns could occur from LTE operations to DTV services,

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of Allotments we address IM3 interference through the use of spacing requirements.<sup>163</sup> IM3 interference was not considered either for the development of the transition or the final DTV Table of Allotments and is not considered in decisions regarding the acceptability of new applications or modifications to existing station facilities.<sup>164</sup>

47. As indicated above, Off Frequency Rejection (OFR) is a reduction in a receiver's susceptibility to interference when the channel to which it is tuned is not fully co-channel to the interfering signal, considering both the out-of-band emissions (OOBE) of the transmitter and the adjacent-channel selectivity (ACS) of the receiver.<sup>165</sup> NAB does not object to the use of OFR, but challenges the OFR-based D/U values proposed in Table 9 of the *ISIX PN* because they do not take into account asymmetry in interference rejection that occurs in a DTV receiver based on where the spectral overlap occurs.<sup>166</sup> Specifically, NAB disagrees with the values of the OFR where the spectral overlap equals 1 MHz.<sup>167</sup> While we recognize such asymmetry in the performance of DTV receivers, the D/U values adopted in our ISIX Methodology are sufficiently conservative to protect against interference from wireless signals on co-channel and adjacent-channel frequencies above or below a received television channel.<sup>168</sup> Therefore, NAB's objections to our OFR values are misplaced. In addition, the adopted values will protect adjacent-channel operations, by several dB or more.<sup>169</sup> Accordingly, we adopt the values for OFR set forth in Table 9 of the *ISIX PN*.

48. *Clutter Loss.* We decline to adopt the proposed use of clutter loss for Case 3 for reasons similar to those set forth above with regard to Case 2.<sup>170</sup> Clutter loss has not been used in the context of interference between television stations, and we conclude that application of a single clutter value in a four-square kilometer area would not improve the accuracy of the ISIX Methodology.<sup>171</sup>

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we believe that the cellular nature of the LTE operations would minimize the statistical likelihood that such interference effects would actually affect DTV services.

<sup>163</sup> See NAB *Measurements PN* Comments at 14, n. 33.

<sup>164</sup> See 47 C.F.R. § 73.616 (rules do not consider DTV-to-DTV IM3 interference).

<sup>165</sup> See *supra*, n. 123.

<sup>166</sup> See NAB *Measurements Comments* at 14-15. Asymmetry can be manifested in either edge of the signal.

<sup>167</sup> See NAB *Measurements Comments* at 17.

<sup>168</sup> The D/U ratios we are adopting for +1 MHz spectral overlap will provide a D/U threshold of  $9.3 + \alpha$ , where  $\alpha$  is the signal-to-noise ramp function. In the case of a moderate desired signal level (-54.7 dBm) that NAB points to,  $\alpha$  will be nearly 0 dB and the D/U threshold for a +1 MHz overlap will be approximately 9.3 dB. This threshold between 1.8 and 21.7 dB is greater than OET's measured required LTE-to-DTV D/U values on either the upper or lower edge of the DTV signal.

<sup>169</sup> See *Measurements PN* at 14 (measurements at 0 MHz spectral overlap show D/U ratios of at least -35 dB while our D/U ratio for 0 MHz in the ISIX Methodology is -2 dB – 33 dB more conservative).

<sup>170</sup> While the wireless community supports the use of clutter, see *Transmit Comments* at 3, *4G Americas Comments* at 9, *CTIA Comments* at 7, the Joint Broadcasters oppose it, arguing that the application of clutter adjustments “severely and artificially understates undesired signal strength while overstating desired signal strength,” that there is no technical rationale for applying clutter in only some of the interference scenarios and not others, and that there is no basis for choosing one clutter value for a four-square kilometer area. Joint Broadcasters *Comments* at 25-26. Joint Broadcasters also claim that clutter should not be used in determining separation distances necessary between DTV and wireless base stations. *Id.* at ii, 25-28; see also SBE *Comments* at 4 (“inclusion of clutter losses in the analysis does not provide a sufficiently conservative and safe result and may well under-predict interference”).

<sup>171</sup> See *supra*, para. 36.

49. *Propagation Model.* We reject suggestions that the ISIX Methodology use the Hata<sup>172</sup> or the free space propagation model<sup>173</sup> for Case 3 instead of the Longley-Rice model. The Commission has relied on the Longley-Rice model to predict television coverage and interference for more than fifteen years, and that model is widely accepted for use at the frequencies in the 600 MHz Band.<sup>174</sup> While several commenters argue that the Hata model is better suited for wireless networks, the Hata model was not intended for use at large distances and does not take account of terrain, which is an important consideration over the large distances associated with broadcast services.<sup>175</sup> Even at shorter distances, terrain is an important consideration in predicting inter-service interference because it affects signal propagation. The Longley-Rice model also can predict diffraction and scattering losses over multiple terrain obstructions at much larger distances more accurately than the Hata model.<sup>176</sup> In addition, we believe that the use of a single model capable of accurate prediction over different distances is preferable to the use of multiple models.<sup>177</sup> Accordingly, we disagree with 4G Americas that we should use the Hata model to predict interference from wireless base stations to DTV receivers at distances of less than 40 kilometers.<sup>178</sup> Likewise, we disagree with SBE that we should use the free space model for distances of less than five kilometers.<sup>179</sup>

<sup>172</sup> The Hata model (also referred to as Okumura-Hata model) is based on empirical measurements and is valid from 150 MHz to 1500 MHz. See Hata, Masaharu, *Empirical Formula for Propagation Loss in Land Mobile Radio Services*, IEEE Transactions on Vehicular Technology, Vol. VT-29, No. 3, pp. 317-325, August 1980 (Hata Paper). The Hata model extended the Okumura model to derive correction factors for city and suburban environments. See <http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1622772&isnumber=34048>. Okumura, T., Ohmori, E., and Fukeda, K., *Field Strength and Its Variability in VHF and UHF Land Mobile Service*, Review Electrical Communication Laboratory, Vol. 16, No. 9-10, pp. 825-873, September-October 1968. See CTIA Comments at 7 (noting that models other than Longley-Rice may be preferable given the differences between LTE and high powered broadcast television transmission); 4G Americas Comments at 8-9 (supporting use of the Hata model for distances over 40 kilometers because it was originally developed for non-line-of-sight signal propagation paths in urban environments that are typical of mobile wireless services); Ericsson Comments at 5 (supporting use of the extended Hata propagation model);

<sup>173</sup> The free space propagation model assumes that radio signals are attenuated only by the spreading that occurs with distance. SBE Comments at 5 (supporting use of a free space propagation model for distances of less than five kilometers).

<sup>174</sup> ISIX PN, 29 FCC Rcd at 717; see also OET-69.

<sup>175</sup> See *supra* n. 164 (Hata Paper). The empirical Hata model is not as well suited for propagation prediction over irregular terrain as is the deterministic Longley-Rice model. See Rappaport, T. S., *Wireless Communications: Principles and Practice*, Prentice Hall, 2nd Edition, 2002, at 145-152. Further as indicated by commenters, the Hata model is not intended for use at distances larger than 40 kilometers. See 4G Americas Comments at 9, Ericsson Comments at 5; see also Ericsson Comments at 6 (recognizing that the Longley-Rice model has certain advantages including the “validity of long distances and can handle the effect of curvature of the earth”).

<sup>176</sup> See Kasampalis, S., et. al., *Comparison of Longley-Rice, ITU-R P.1546 and Hata-Davidson propagation models for DVB-T coverage prediction*, IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), 2014.

<sup>177</sup> As demonstrated by Sprint, the Longley-Rice model produces results akin to both the Hata model and the FCC curves at distances on the order of tens of kilometers. See Sprint Comments at 5-6, 16-28.

<sup>178</sup> 4G Americas Comments at 9 (supporting the use of Hata for distances less than 40 kilometers and Longley-Rice over longer distances).

<sup>179</sup> See SBE Comments at 5. We note that the Longley-Rice model uses a free-space propagation model over short distances. See NTIA Report 82-100, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode*, authors G.A. Hufford, A.G. Longley and W.A. Kissick, U.S. Department of Commerce, April 1982, Figure 1 at 11, Section 4 at 17.

50. *Fixed Distance-Based Approach.* We also reject Joint Broadcasters' fixed distance-based approach for Case 3.<sup>180</sup> Their approach predicts wireless license area impairments greater than those predicted by the ISIX Methodology in some cases, whereas in others it would produce similar results or result in smaller impairments.<sup>181</sup> The critical difference between the two approaches for Case 3, however, is the granularity of the data. The fixed geographic distances under the Joint Broadcasters' approach are not easily converted to the "grid-by-grid" data needed to evaluate potential harmful interference to television stations in the initial optimization process during the auction.<sup>182</sup> The ISIX Methodology provides for a cell-by-cell determination of license impairments which will allow the Commission to make more informed decisions about the appropriate clearing targets for the reverse auction and which wireless spectrum blocks to auction in the forward auction, and also provide additional certainty to bidders in the forward auction.<sup>183</sup> Therefore, we conclude that the ISIX Methodology is better suited to the requirements of conducting the incentive auction than a distance-based approach for Case 3.

51. *Technical Parameters.* We reject broadcasters' claims that the parameter values for wireless base station power and height proposed for Case 3 in the *ISIX PN* are inconsistent with real-world wireless facilities.<sup>184</sup> As discussed below, these typical values were obtained from advisory committees and industry submissions in the record. The Commission has previously considered typical operating parameters in predicting interference, rather than assuming the maximum permissible levels authorized under the Commission's rules.<sup>185</sup> As Sprint notes, the typical parameters may not precisely

<sup>180</sup> Joint Broadcasters propose using the distance tables specified in section 27.60 of our rules, noting that the distances would be based on actual DTV operating facilities. *See* Joint Broadcasters Comments at 39-40; *see also* 47 C.F.R. § 27.60(b); *but see* CTIA Comments at 6-7 ("[U]sing a rigid approach such as that previously utilized by the Commission under Section 27.60 of the rules, or any other pre-defined radius for exclusion zones, would result in spectral inefficiency, something that simply cannot be afforded given the current spectrum shortage."). Joint Broadcasters propose to use the FCC F(50, 10) curves along with the D/U ratios specified in Table 8 of the Appendix to the *ISIX PN* to adjust the distances for specific co-channel or adjacent channel frequency overlap. *See* Joint Broadcasters Comments at 39-40. The separation distances would be calculated using the desired DTV signal level set nominally to 41 dBμ (DTV contour) with D/U ratios applied to determine the applicable F(50,10) field strength contour using the maximum antenna height and transmitter power for the wireless base station permitted under the 600 MHz rules. *See id.* Wireless operation outside these distances would be deemed unimpaired.

<sup>181</sup> Joint Broadcasters' approach consistently predicts larger impairments than the ISIX Methodology where the operations are co-channel (*i.e.*, where the spectral overlap between television and wireless is between 1 and 5 MHz). Where the operations are adjacent channel (*i.e.*, where the spectral overlap is between -5MHz and 0), the Joint Broadcasters' approach may predict smaller impairments than the ISIX Methodology.

<sup>182</sup> *See Incentive Auction R&O*, 29 FCC Rcd at 6620-21, para. 116.

<sup>183</sup> As stated above, we will address exactly how to use the ISIX Methodology's results in conducting the incentive auction in the forthcoming *Comment PN* on final auction procedures. *See supra*, para. 24.

<sup>184</sup> Joint Broadcasters Comments at 13. *See* SBE Comments at 7. We disagree with the Joint Broadcasters' claim that assuming ten kilometer uniform spacing of wireless base stations underestimates the potential for wireless interference to television stations. *See* Joint Broadcasters *ISIX PN* Comments at 17-18. Because we designate an entire county as restricting even if only a single base station within the county is predicted to cause interference, we do not believe an assumption underestimates the potential for interference. Similarly, we believe our decision to designate an entire county as restricted even if only a single base station causes interference is reasonable in light of the need to assume a hypothetical deployment of base stations. *See* CTIA Comments at 7; Sprint Comments at 13.

<sup>185</sup> *See* Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems, ET Docket No. 98-153, Memorandum Opinion and Order, 18 FCC Rcd 3857, 3908, ¶ 130 (2003) (rejecting interference analysis that assumed that UWB devices would operate at peak power limit authorized in FCC rules), *aff'd* 19 FCC Rcd 24588, 24600, ¶ 94 (2004), *aff'd* 25 FCC Rcd 11390 (2010); *see also* Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices, ET Docket No. 99-231, *Report and Order*, 15 FCC Rcd 16244, 16248 para. 11 (2000) (FCC makes assumptions about real world scenarios rather than assuming equipment operates at maximum power); Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band, ET Docket No. 03-122, *Report and Order*, 18 FCC

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reflect the parameters that a wireless provider would use in actual deployment, but they are reasonable for purposes of modeling.<sup>186</sup> We emphasize that the use of typical values for Case 3 will be restricted to the incentive auction, when actual values will not be available because 600 MHz Band services will not be deployed yet; in the companion *FNPRM*, we propose to use actual values to prevent Case 3 interference following the auction, once 600 MHz Band wireless services actually are deployed.<sup>187</sup>

52. For purposes of the auction, the ISIX Methodology assumes an Effective Radiated Power (ERP) level of 120 W/MHz for a wireless base station. This power level, which is supported by data in the record, is based on a wireless base station operating with two LTE transmitters, rated at 40 watts (W) each and transmitting at their maximum capable output power (ignoring network effects such as power control) and an antenna gain of 15 dBi.<sup>188</sup> The 15 dBi value is based on manufacturer data on panel antennas designed for operation in frequency bands above and below the 600 MHz Band.<sup>189</sup> An antenna with 15 dBi gain used with two 40 W transmitters and a line loss of 1 dB produces an ERP of 1200 W in a 10 MHz LTE channel, or 120 W/MHz ERP.<sup>190</sup> To simulate the effect on one 6 MHz television channel of wireless operations transmitting across contiguous adjacent 5 MHz wireless blocks, OET multiplied the ERP/MHz by 6, so that the ERP in a 6 MHz channel would be 720 watts.<sup>191</sup>

53. The antenna Height Above Average Terrain (HAAT) value of 30 meters we adopt for use in the ISIX Methodology is consistent with real-world network information incorporated in the Commerce Spectrum Management Advisory Committee (CSMAC) Final Report.<sup>192</sup> This report specifies

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Rcd 2448, 2458, n. 50 (2003) (FCC assumes not all operations will be conducted at maximum power limit); *see also* Improving Public Safety Communications in the 800 MHz Band, ET Docket No. 00-258, *Supplemental Order and Order on Reconsideration*, 19 FCC Rcd 25120, 25139, para. 41 (2004) (FCC selects interference thresholds that fall within the “range of reason”).

<sup>186</sup> Sprint Comments at 5, n. 6 and 10. Sprint notes that “each auction bidder can, on its own accord, make adjustments to the interference assessment it uses to inform its bidding decision (and deployment choices), based on its specific guidelines and expectations.” *Id.*

<sup>187</sup> *See infra*, *FNPRM* at paras. 68-72.

<sup>188</sup> *See ISIX PN*, 29 FCC Rcd at 733; Letter from Steve B. Sharkey, Chief, Engineering and Technology Policy for T-Mobile USA, Inc. to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268 (filed May 7, 2014), (“T-Mobile Letter”) (noting that “[f]or LTE base station power, typical LTE equipment is configured to transmit at 43 dBm [20 watts] for tower top mounted radio units and 46 dBm [40 watts] for ground based radio units. Antenna gain, MIMO, and different LTE channel bandwidths increase the maximum equivalent isotropically radiated power (EIRP) of the base station transmitter per the transmitter characteristics submitted to CSMAC.”); Commerce Spectrum Management Advisory Committee (CSMAC), LTE (FDD) Transmitter Characteristics, at 1, available at [http://www.ntia.doc.gov/files/ntia/meetings/lte\\_technical\\_characteristics\\_0.doc](http://www.ntia.doc.gov/files/ntia/meetings/lte_technical_characteristics_0.doc) (last visited May 6, 2014) (CSMAC data, showing values within 1dB of those we adopt in this Order; <http://www.alcatel-lucent.com/products/multi-carrier-remote-radio-head> (last visited Apr. 30, 2014) (indicating availability of 2x40W LTE transmitters from wireless equipment manufacturers); *Incentive Auction R&O*, 29 FCC Rcd at 7001, App. C, n. 197 (showing detailed power calculations supporting the values in the Order).

<sup>189</sup> OET evaluated several commercially available panel antennas made by well-known manufacturers that operate on bands near the 600 MHz Band. Antennas intended for operation in frequencies between 400 and 500 MHz (CommScope DB654DG65A-C and Kathrein 741518) had an average gain of approximately 14 dBi. Antennas intended for operation in frequencies between 700 and 900 MHz (CommScope 5UPX0805F, SBNH-1D4545A, and SBNH-1D6565B-V1; and RFS APX75-864014-CT0 and APX75-866512-CT0) had an average gain of approximately 16 dBi. Based on the average of these typical antenna gains, we expect that a typical panel antenna in the 600 MHz Band will have a gain of approximately 15 dBi (12.8 dBd).

<sup>190</sup> 19 dBW (80watts) – 1 dB + 12.8 dBd (15 dBi) = 30.8 dBW ~ 1200 W / 10 MHz channel = 120 W/MHz.

<sup>191</sup> *ISIX PN*, 29 FCC Rcd at 733, n. 22.

<sup>192</sup> *See* Commerce Spectrum Management Advisory Committee, Working Group 1 – 1675-1710 MHz Meteorological-Satellite, at Appendix 3-5, Final Report, Rev. 1, available at

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30 meters as the typical HAAT for base stations in urban/suburban areas where inter-service interference would most likely occur. The wireless industry also supports this assumption.<sup>193</sup> The Joint Broadcasters' analysis overestimates the typical wireless base station antenna height because it is based on the overall height above ground level for the towers hosting a wireless antenna, rather than the height at which the wireless antennas are actually mounted on each tower.<sup>194</sup> Wireless antennas are typically side-mounted on platforms or other supporting structures, resulting in a much lower antenna height than the overall tower height.<sup>195</sup> Moreover, while the Joint Broadcasters' analysis relies on data from American Tower, one of the largest tower management entities in the United States, it excludes rooftop, on-building, and broadcast tower mounted sites.<sup>196</sup> For the above reasons, we believe that the typical values we adopt are appropriate for modeling a 600 MHz Band wireless network.

54. *"Error Code 3" Messages.* We disagree with the Joint Broadcasters that we should assume service in cells where an "error code 3" message appears, rather than using the predicted field strength at such locations. The Joint Broadcasters' claim that our approach departs from the Commission's treatment of error warnings ignores the fact that we have treated error warnings differently depending on context.<sup>197</sup> In the *Incentive Auction R&O*, we decided to assume service in cells where an "error code 3" message appears, because doing so is consistent with the traditional assumption for purposes of applying the OET-69 methodology that service is available throughout a station's coverage area and that broadcasters locate and configure their transmitters to maximize coverage.<sup>198</sup> In predicting Case 3 interference, however, we find that different treatment of "error code 3" messages is appropriate. If we were to assume service in the presence of an error warning, the cell in question would be treated as having interference-free service, meaning that potential inter-service interference would be ignored. The result would be a failure to check for inter-service interference at locations where the DTV signal could

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[http://www.ntia.doc.gov/files/ntia/publications/wg1\\_report\\_07232013.pdf](http://www.ntia.doc.gov/files/ntia/publications/wg1_report_07232013.pdf) (CSMAC Final Report) (the same table provides for antenna height of 45 meters for rural deployment).

<sup>193</sup> See Letter from Steve B. Sharkey, T-Mobile USA, Inc. to Marlene H. Dortch, GN Docket No. 12-268, at 1, n.1 (May 7, 2014) (T-Mobile Ex Parte) (noting that T-Mobile's mean antenna height above ground is approximately 31 meters, with lower and higher variations in different parts of the country).

<sup>194</sup> See Joint Broadcasters Comments at 12-15. See, e.g., Letter from Steve B. Sharkey, Chief, Engineering and Technology Policy for T-Mobile USA, Inc. to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-268 (filed May 7, 2014), ("T-Mobile Letter"). T-Mobile specifies its "mean antenna height above ground" is "approximately 31 meters," with a range between 15 and 45 meters. If T-Mobile's antennas were top-mounted, they would be closer to the 50 to 75 meter range asserted by Joint Broadcasters. See Joint Broadcasters Comments at 13-14. In wireless telecommunications systems, the tower is the supporting structure, and the antenna is the radiating structure. Thus, the antenna height, rather than the tower height, would be the factor to consider in interference analyses from these wireless systems.

<sup>195</sup> These sites include antenna installations on public or private structures, such as buildings, light poles, and water towers, many of which are lower than the heights cited by Joint Broadcasters. See *Acceleration of Broadband Deployment by Improving Wireless Facilities Siting Policies*, WT Docket No. 13-238, Notice of Proposed Rulemaking, 28 FCC Rcd 14241 (2013) (noting that modern wireless antennas are often mounted on "utility poles, street lamps, water towers, or rooftops").

<sup>196</sup> See Joint Broadcasters Comments at 13-14. Along with American Tower, Crown Castle International, SBA Communications, and KGI Wireless round out the top four companies in the United States that own or manage more than 10,000 structures. However, there are many other smaller tower owners and managers, as well as many towers which are owned and managed by wireless providers themselves. See FCC Antenna Structure Registration (ASR) database, which consists mainly of antenna structures taller than 200 feet or located in an airport glide slope path. See also [http://www.wirelessestimator.com/t\\_content.cfm?pagename=US-Cell-Tower-Companies-Complete-List](http://www.wirelessestimator.com/t_content.cfm?pagename=US-Cell-Tower-Companies-Complete-List) for an unofficial list of tower owner and management companies.

<sup>197</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6640-41, para. 160.

<sup>198</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6640-41, para. 160.

be subject to interference.<sup>199</sup> By instead using the predicted field strength at such locations, we will ensure that the ISIX Methodology evaluates service and potential interference in the flagged cells just as it would in non-flagged cells. Our approach does not alter or otherwise affect our treatment of error warnings in applying the OET-69 methodology as set forth in the *Incentive Auction R&O*.

55. *Aggregate Wireless Interference to DTV.* We decline to consider the potential impact of interference from multiple wireless base stations on DTV reception when applying the ISIX Methodology for Case 3 during the incentive auction. Broadcasters express concern that LTE signals could combine at the point of DTV signal reception, increasing the potential for interference.<sup>200</sup> They urge the Commission to use either a simple direct summation of signals or the Root Square Sum (RSS) method<sup>201</sup> for calculating interference from multiple DTS transmitters under our current rules.<sup>202</sup> We conclude that neither of these approaches is appropriate here because the ISIX Methodology necessarily relies on hypothetical placement of wireless base stations every ten kilometers with no regard to whether actual operation on those locations is desirable or possible. First, the hypothetical wireless base stations are placed even within the contours of television stations – a situation that will not occur in reality. Therefore, aggregating the interference from those hypothetical base stations would not provide any meaningful information and would not improve the accuracy of the ISIX Methodology.<sup>203</sup> We also observe that in order to manage interference within their systems, wireless providers may not operate on a given frequency block simultaneously at all of their cell sites. Thus, aggregating signals from all of the hypothetical base stations would not improve our estimates of impairments, would tend to produce a “worst case” scenario, and overestimate potential interference. Moreover, the patterns of frequency use that would be optimal for wireless providers are not clear because they would vary with terrain and other considerations. As a result, it would not improve the accuracy of the impairment estimates to assume a

<sup>199</sup> The most common cause of the “error code 3” warning message is that the absolute value of the angle to the horizon from either the transmitter or receiver exceeds 200 milliradians. Since the ISIX Methodology will assume hypothetical wireless base station locations uniformly placed every ten kilometers at 30 meters HAAT, this warning message will likely occur more frequently than with actual transmitters placed for optimal coverage in light of terrain conditions. However, a staff comparison of Longley-Rice model versus Television Allocations Study Organization (TASO) measured data shows a difference in median value of absolute error between the predicted value and the measured value of less than 1 dB when the warning flag is present. Staff examined TASO measured data for sites KJEO (Fresno, California), WAFB (Baton Rouge, Louisiana), WBRE (Wilkes Barre, Pennsylvania), WBUF (Buffalo, New York), WHYY (Philadelphia, Pennsylvania), WHYN (Springfield, Massachusetts), WMTV (Madison, Wisconsin) and WUHF (New York, New York), comparing two thousand forty five points. Approximately 38 percent of those points generated an “error code 3” warning message. The difference in the median error when a warning message was generated was 0.8 dB.

<sup>200</sup> See, e.g., SBE Comments at 6, Joint Broadcasters Comments at ii, 15-18.

<sup>201</sup> The RSS method squares the signal strength levels of the individual signals to be aggregated, adds those values, and takes the square root of the sum. As multiple wireless transmitters are expected to be located at different distances from a DTV receiver, their signals will not be fully synchronized and so there should be no correlation of their signals. With uncorrelated signals, the instantaneous power is not synchronized, and the peaks, lows, and intermediate levels of the individual signals will add together to be a higher value when both signals are at high levels and cancel each other when one is at a high level and the other is at a low level. The RSS method is for determining the combined signal level in such cases. See Qualcomm Incorporated Petition for Declaratory Ruling, WT Docket No. 05-7, Order, 21 FCC Rcd. 11683 (2006).

<sup>202</sup> Joint Broadcasters Comments at 17.

<sup>203</sup> The ISIX Methodology assumes a hypothetical deployment of wireless base stations uniformly spaced at ten kilometers apart when predicting interference from wireless base stations to DTV. See *ISIX PN*, 29 FCC Rcd at 725; see also, App. A, Technical Appendix at para. 16. Aggregating the potential interference of each hypothetical base station in each cell at a distance of 500 kilometers in all directions from the DTV station could result in aggregating up to nearly 8,000 hypothetical base stations. The aggregation of this many hypothetical locations is neither practical nor realistic.

standard frequency re-use pattern for the ISIX methodology. We also note that aggregating the signal strengths from each hypothetical wireless base station within the 500 kilometer culling distances of a co-channel or adjacent channel television station could result in impairing all, or nearly all, of the locations considered. That is because locations whose own contributions to interference would be below the D/U threshold could be considered sources of interference when interference is aggregated with other hypothetical base stations. Also it might be more useful for wireless providers to have impairment information based on the individual wireless base station. Finally, our plan to consider a whole county impaired if even one of the hypothetical ten-by-ten kilometer cells located in that county is predicted to cause interference will provide a conservative approach in establishing impairments that should address Joint Broadcasters' concerns. Therefore, because the RSS method would not improve the accuracy of our estimates of interference potential during the auction, it will not be used when determining impairments to the wireless licenses during the auction. We seek comment in the *FNPRM* on how to assess potential aggregate interference from wireless base stations to DTV reception based on actual deployments of 600 MHz Band services following the auction.<sup>204</sup>

**(ii) Case 4: Wireless User Equipment to Digital Television Receiver**

56. We adopt fixed geographic separation distances for Case 4. Specifically, wireless user equipment (i.e. mobile and portable devices) will be prohibited from co-channel or adjacent-channel operations within a television station's contour and within a set distance from the station's contour. We determine that the appropriate distance is five kilometers for co-channel operations, as suggested by NAB, and one-half kilometer for adjacent-channel operations.<sup>205</sup>

57. We find that a simple, fixed-distance approach is warranted for Case 4 because it involves short distances only. Wireless user equipment transmits at relatively low power and its location is usually closely bound to the vicinity of its associated base station.<sup>206</sup> In addition, outdoor operation of wireless user equipment usually involves heights above ground on the order of 1.5 meters, resulting in significant attenuation of signals by ground clutter. Wireless user equipment operating in buildings may be significantly higher than 1.5 meters, but signals are significantly attenuated by walls indoors. As a result of these factors, the potential for wireless user equipment to cause harmful interference to television service operating co-channel or adjacent channel occurs only at short distances of a few kilometers. At these distances, the number of grid cells in a television station's coverage area that could be affected by wireless user equipment is limited to a few cells in the interference range of the devices rather than all of the cells in the station's coverage area. In addition, the Longley-Rice Model is not designed for distances less than a kilometer and relies on either free-space or line-of-sight predictions for such distances.<sup>207</sup> We

<sup>204</sup> See *infra*, *FNPRM* at para. 70. We note that, under the approach we adopt for Case 3 during the auction, the ISIX Methodology effectively will treat all hypothetical base stations in each county as causing interference.

<sup>205</sup> See *ISIX PN*, 29 FCC Rcd at 727. (indicating that the NAB suggested a uniform separation distance of five kilometers for co-channel operations). Therefore, wireless licenses that will be co-channel or adjacent-channel to a television station in the uplink 600 MHz spectrum, will have impairments that cover the area of the station's contour and an additional five kilometers if the television station is co-channel, or one half kilometer if the television station is adjacent channel to the wireless operations.

<sup>206</sup> Wireless User Equipment is assumed to transmit with a radiated power of 0.12 W/5MHz ERP and operate at a height of 1.5 meters. See App. A, Technical Appendix at n.22; see also *ISIX PN*, 29 FCC Rcd at 734 (Table 11).

<sup>207</sup> See Table 1, NTIA Report 82-100, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode*, G.A. Hufford, A.G. Longley and W.A. Kissick, U.S. Department of Commerce, April 1982. The original design limitations to the ITS ITM specified an input distance range between one and 2,000 kilometers. See also Daniel, W. and Wong, H., "Propagation in Suburban Areas at Distances less than Ten Miles," *FCC/OET TM 91-1*, Federal Communications Commission, Office of Engineering and Technology, January 25, 1991." <http://www.fcc.gov/oet/info/documents/technical/tm91-1.pdf>. This report states that prediction models like Longley-Rice "are generally intended for use at greater distances and were based on, and verified with, empirical

(continued....)

also observe that use of site-by-site Longley-Rice evaluations for Case 4 would necessitate the development of complex and detailed maps of locations where user equipment can operate.

58. In view of these considerations, we find that a separation distance approach can adequately protect that station's service. Such an approach is also more administratively efficient for wireless service licensees because it will avoid the need for computerized evaluations required by the Longley-Rice model and maps of locations where wireless user equipment may operate. Instead, wireless providers will be able to design their networks to avoid operation of wireless end user equipment within the contour of television station and within the specified separation distances. For these reasons, we conclude that applying the Longley-Rice propagation model is not warranted for Case 4.<sup>208</sup> Applying the Longley-Rice model would increase the ISIX Methodology's complexity without resulting in more accurate interference predictions. We therefore will use a straightforward distance separation approach discussed above for Case 4.<sup>209</sup> As described in the Technical Appendix, we find that the appropriate model for the short distances associated with Case 4 is the OET TM91-1 propagation model.<sup>210</sup> Using this model we calculated that broadcast television service will be protected from interference from wireless user equipment if such devices are not permitted to operate within the contours of the television station and within five kilometers if co-channel or a half kilometer if operating on the adjacent channel.

**c. The Spectrum Act Does Not Preclude Use of the ISIX Methodology and Input Values to Predict or Prevent Inter-Service Interference**

59. We reject the Joint Broadcasters' claim that section 6403(b)(2) of the Spectrum Act limits our authority to adopt the ISIX Methodology and input values to address inter-service interference.<sup>211</sup> Section 6403(b)(2) requires the Commission, in "making any reassignments or reallocations," to "make all reasonable efforts to preserve, as of [February 22, 2012], the coverage area and population served of each broadcast television licensee, as determined using the methodology described in OET Bulletin 69 . . . ."<sup>212</sup> The Joint Broadcasters argue that our efforts "to preserve" broadcasters' coverage area and population served from inter-service interference will violate section 6403(b)(2) unless we use "the methodology described in OET Bulletin 69."<sup>213</sup>

(Continued from previous page)

data from these greater distances." When predicting field strengths at shorter distances, these models "generally revert to classical free space or plane earth propagation equations at these shorter distances," depending on the "first Fresnel zone clearance between the transmitting and receiving antennas,"

<sup>208</sup> As the *ISIX PN* acknowledged that the Longley-Rice model may not be appropriate for Case 4 because it involves short distances. *ISIX PN*, 29 FCC Rcd at 717, n. 12.

<sup>209</sup> We note that the application of this distance requirement applies to wireless providers who would manage their network to ensure that spacing distance is properly maintained. This requirement would not be apparent to wireless users and would not require them to take any actions to affect compliance.

<sup>210</sup> See FCC/OET TM 91-1, Federal Communications Commission, Office of Engineering and Technology, January 25, 1991, <http://www.fcc.gov/oet/info/documents/technical/tm91-1.pdf>

<sup>211</sup> See Joint Broadcasters Comments at 4-8; see also *NAB Measurements PN* Comments at 5.

<sup>212</sup> Spectrum Act § 6403(b)(2).

<sup>213</sup> See Joint Broadcasters Comments at 3 ("Use of the proposed new OET methodology as a basis for interference protection following the auction would contravene provisions of the Spectrum Act, which require the Commission to preserve the coverage area and population served of broadcast stations in accordance with OET-69."); *id.* at 6 (referring to the duty to use "all reasonable efforts" to preserve coverage area and population served "using the OET-69 methodology"); see also *NAB Measurements PN* Comments at 5 (stating that if "the Commission intended to use [the methodology proposed in the *ISIX PN*] as a basis for interference protection following the auction," such a result "would contravene the express provisions of the Spectrum Act and would prove legally unsustainable").

60. We disagree.<sup>214</sup> As we explained in the *Incentive Auction R&O*, the coverage area and population served of broadcasters, including any assigned to spectrum in the 600 MHz Band, must be “determined” using “the methodology described in OET Bulletin 69,” as required by section 6403(b)(2).<sup>215</sup> The ISIX Methodology and input values we adopt in this Order (for use during the auction) and propose in the *FNPRM* (for protecting broadcasters from inter-service interference following the auction) will not be used to “determine[]” coverage area and population served. Rather, they will be used “to preserve” the coverage area and population served that we have already “determined” through the methodology set forth in the *Incentive Auction R&O*.<sup>216</sup> These efforts are not restricted by the statute’s reference to “the methodology described in OET Bulletin 69.”<sup>217</sup>

### III. FURTHER NOTICE OF PROPOSED RULEMAKING

61. While the companion *Second Report & Order* addresses how we will predict inter-service interference before 600 MHz Band wireless networks have been deployed for purposes of the incentive auction, in this *FNPRM* we seek comment on proposed rules to govern the interference relationship between broadcast television and wireless service in the 600 MHz Band following the incentive auction. As discussed in the *Second Report & Order*, we anticipate that after the auction some broadcast television stations may operate on channels in the 600 MHz Band as a result of market variation.<sup>218</sup> We propose to allow no harmful interference from wireless operations to reception of television service. There are two scenarios that present the potential for harmful interference to television stations, depending on whether a station is assigned to the 600 MHz Band downlink or uplink spectrum.<sup>219</sup> First, if a station is located in the downlink spectrum, we will need to protect against harmful interference from wireless base stations to

<sup>214</sup> We note that the broadcasters’ arguments are misplaced insofar as the ISIX Methodology adopted in this *Second Report and Order* is concerned. As discussed above, we will use the ISIX Methodology we adopt here during the incentive auction only. Issues pertaining to the *preservation* of existing broadcast service in an inter-service interference environment following the incentive auction are discussed in the *FNPRM*. Nonetheless, because broadcasters have put forth a statutory claim, we address that claim here.

<sup>215</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6575, para. 19. Joint Broadcasters claim that the “Spectrum Act specifies the methodology that must be used in the incentive auction to determine coverage area and population served for each broadcaster,” but “the Commission has not articulated an interpretation of Section 6403(b)(2) of the Spectrum Act that would permit the use of a different methodology.” Joint Broadcasters Comments at 9. In fact, we are not using a “different methodology” to determine coverage area and population served. As required by Section 6403(b)(2), we will use “the methodology described in OET Bulletin 69” to make such determinations.

<sup>216</sup> OET Bulletin 69 provides for evaluating potential interference between television stations, but it does not provide for evaluating the impact of wireless operations on television station operations. In other words, as the Joint Broadcasters seem to acknowledge by advocating a fixed distance-based approach in contradiction to their statutory argument, OET Bulletin 69 is not designed to predict inter-service interference. See OET Bulletin 69 at 7; see also Joint Broadcasters Comments at 39-40 (supporting a fixed-distance approach to preventing inter-service interference rather than “the methodology described in OET Bulletin 69”). We note, however, that the Commission has used OET Bulletin 69, with adjustments, to predict interference between wireless services and television stations, see *Qualcomm Incorporated Petition for Declaratory Ruling*, WT Docket No. 05-7, Order, 21 FCC Rcd 11683 (2006), and that the ISIX Methodology we adopt uses some of the major concepts in the methodology described in OET Bulletin 69.

<sup>217</sup> As the Joint Broadcasters acknowledge, “Section 6403(b)(2) provides the standard against which the adequacy of the incentive auction and repacking process must be measured: namely, coverage area and population served of each broadcast station using OET-69 . . . . In conducting the incentive auction, the Commission ‘shall make all reasonable efforts’ to preserve those values . . . .” See Joint Broadcasters Comments at 5.

<sup>218</sup> See *supra*, para. 26.

<sup>219</sup> We will address where to place any broadcast television stations that are assigned channels in the 600 MHz Band in the forthcoming *Comment PN*.

TV receivers (Case 3).<sup>220</sup> Second, if a station is located in the uplink spectrum, we will need to consider interference from wireless user equipment to TV receivers (Case 4).<sup>221</sup> As an initial matter, the *FNPRM* addresses the level of inter-service interference to television stations in the 600 MHz Band that should be permitted. We also propose a methodology for new 600 MHz Band licensees to predict whether wireless operations will interfere with television stations in the 600 MHz Band in order to identify the “permitted boundaries” of wireless license areas following the auction.<sup>222</sup> Specifically, for Case 3 scenarios, we seek comment on requiring wireless licensees to use proposed OET Bulletin No. 74 (OET-74), which is attached as Appendix E.<sup>223</sup> For Case 4 scenarios, we propose to adopt the same fixed separation distances adopted in the companion *Second Report & Order* for use in the incentive auction.<sup>224</sup> In the event that wireless operations actually cause harmful interference to television reception in the 600 MHz Band where interference was not predicted to occur, we also propose to require wireless providers to take action to eliminate the interference.

62. We also seek comment in this *FNPRM* on procedures to prevent inter-service interference following the incentive auction. We propose to require wireless providers to analyze potential interference to any co-channel or adjacent channel television station in the 600 MHz Band within a set distance using the methodology in OET-74 before deploying base stations, regardless of whether the wireless license area was identified as “impaired” in the auction. We also propose to allow broadcast television stations in the 600 MHz Band to modify their facilities only to the degree that doing so does not extend their contours in the direction of a co-channel or adjacent-channel 600 MHz Band wireless license area within a set distance.<sup>225</sup>

63. The *FNPRM* also seeks comment on how the ISIX Methodology and inputs adopted in the companion *Second Report & Order* for predicting interference to wireless operations from television stations (Cases 1 and 2) should be modified to predict harmful interference that LPTV and TV translator stations may cause to 600 MHz Band wireless service as it is deployed following the auction. Further, we propose to allow new 600 MHz Band wireless licensees that intend to deploy facilities during the 39-month Post Auction Transition Period<sup>226</sup> to use the ISIX Methodology and inputs, as detailed in the proposed OET-74, to determine whether there is any potential for harmful interference to a television station that has not yet cleared its pre-auction channel in the 600 MHz Band.

64. Finally, we seek comment on how the ISIX Methodology and inputs adopted in the companion *Second Report & Order* can be adapted to predict inter-service interference between wireless services and analog television stations in Canada and Mexico, for purposes of identifying license impairments during the auction.

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<sup>220</sup> See *supra*, paras. 30-31.

<sup>221</sup> See *id.*

<sup>222</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 86 (“licensees with impaired licenses will be limited to operation within the boundaries permitted under the inter-service interference rules we adopt.”)

<sup>223</sup> See App. E.

<sup>224</sup> See *supra*, para. 56.

<sup>225</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 87.

<sup>226</sup> See *Incentive Auction R7O*, 29 FCC Rcd at 6796, para. 559 (defining the “Post-Auction Transition Period” as the 39-month transition period for broadcasters that are assigned new channels in the repacking process and winning UHF-to-VHF and high-VHF-to-low-VHF bidders to relocate to their new channels. The Post-Auction Transition Period will include (1) the three-month period beginning upon the release of the Channel Reassignment PN, during which broadcasters will complete and file their construction permit applications, followed by (2) a 36-month period consisting of varied construction deadline). See *id.*

**A. Protecting Television Stations in the 600 MHz Band from Inter-Service Interference****1. Proposed Threshold for Interference from Wireless Operations to Television Stations in the 600 MHz Band**

65. The *ISIX PN* requested comment on a threshold for interference from wireless operations to television stations in the 600 MHz Band (Cases 3 and 4) of 0.1 percent.<sup>227</sup> Based on examination of the record in this proceeding, we now propose to establish a zero percent threshold for harmful interference. Under this approach, 600 MHz Band wireless licensees would not be permitted to cause harmful interference within the service area of a full power station or the protected contour of a Class A station, to the degree it affects population within that service area or protected contour.<sup>228</sup>

66. We propose this threshold for a number of reasons. First, we believe that a different, more cautious approach may be warranted than in the context of preventing harmful interference between television stations because we will be applying the proposed methodology for the first time.<sup>229</sup> Second, we do not believe that a zero percent interference threshold would undermine our goals for the incentive auction.<sup>230</sup> Third, we are concerned that there is a potential for significant aggregate new interference from wireless operations to television stations if we set a *de minimis* threshold. In the companion *Second Report & Order*, we decline to impose a mandatory one-percent cap on the aggregate new interference that any one television station can receive from other stations as a result of the repacking process, reasoning in part that such a measure is unnecessary because aggregate interference rarely will exceed the 0.5 percent “pairwise” or station-to-station limit, and safety valve measures are available to address exceptional cases of one percent or more aggregate new interference.<sup>231</sup> Here, no such safety valve measures are available, and the risk of significant levels of new aggregate interference is higher. Six megahertz channels in the television bands are aligned, and only a limited number of television stations can operate on the same or adjacent channels in nearby areas. In contrast, varying degrees of spectral overlap between six-megahertz television channels and five-megahertz wireless spectrum blocks in the 600 MHz Band,<sup>232</sup> along with the different technical facilities employed by television and wireless services, create the potential for multiple co- and adjacent-channel relationships between television stations and wireless operations in the 600 MHz Band in the same or nearby geographic areas. Fourth, we do not think that an aggregate threshold for interference to television stations from wireless operations would be either feasible or practical. For these reasons, we propose a zero percent threshold for interference from wireless operations to television stations following the incentive auction.

<sup>227</sup> See *ISIX PN*, 29 FCC Rcd at 718. As noted in the *ISIX PN*, the ISIX Methodology predicts interference from wireless operations to DTV but does not address the limits that should be applied to such interference. See *id.* Wireless commenters support allowing *de minimis* amount of interference. For example, Sprint and 4G Americas believe that interference from wireless service predicted within the DTV service contour should be treated the same way as interference between DTV stations. See 4G Americas at 6; Sprint Comments at 11.

<sup>228</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6643-44, paras. 164-65 (discussing full power stations’ “service area” and Class A stations’ “protected contour”).

<sup>229</sup> The Commission has long applied a 0.5 percent interference threshold to “pairwise” interference between television stations, consistent with the repacking approach we adopted in the *Incentive Auction R&O*. See *Incentive Auction R&O* at 29 FCC Rcd at 6649-51, paras. 176-82.

<sup>230</sup> We conclude in the companion *Second Report & Order* that an aggregate cap on interference to television stations in the repacking process is not only unnecessary but would threaten our goal of a successful auction by unduly slowing down the reverse auction bidding process. See *supra*, para. 16. The proposed zero percent threshold would apply following the incentive auction, however, and should not impact our ability to repurpose spectrum through the repacking process.

<sup>231</sup> See *supra*, paras. 5, 14-15.

<sup>232</sup> See *supra*, para. 29.

67. In the event that interference is predicted between television stations assigned in the 600 MHz Band, we propose to treat that interference as “masking interference” in evaluating wireless interference to a television station. That is, in a grid cell where masking interference to one television station from another is predicted to occur, we propose to ignore the inter-service interference from the wireless operations. This approach would be consistent with the treatment of interference between television stations under our rules.<sup>233</sup> We seek comment on this proposal.

**2. Proposed Methodology and Inputs for Predicting Interference to Television Stations in the 600 MHz Band from Wireless Operations**

**a. Case 3: Interference from Wireless Base Stations to Television Stations Assigned to the 600 MHz Downlink Spectrum**

68. If television stations are assigned to the 600 MHz Band downlink spectrum, we propose to (1) prohibit a wireless licensee from operating base stations within the contour<sup>234</sup> of a co-channel or adjacent-channel DTV station and (2) require the wireless licensee to use the proposed OET-74 to predict interference to such station’s service prior to deploying wireless base stations within a specified culling distance<sup>235</sup> of the station’s contour. We seek comment on these proposals. The culling distances we propose are based on the spectral overlap between wireless operations and broadcast television operations, and the power and antenna height of wireless base stations.<sup>236</sup> We seek comment on this proposal and the specific distances proposed in the attached OET-74. Because there is the potential for impairments in any license that is co-channel or adjacent channel with a broadcast television station, we propose to apply these requirements to all wireless operations within the culling distance that are co-channel or adjacent channel to a broadcast television station, regardless of whether the wireless licensee’s spectrum block was identified as “impaired” in the auction.

69. Our proposed methodology and input values for predicting interference from a wireless base station into DTV service are set forth in detail in the proposed OET-74, attached as Appendix E. The OET-74 methodology is similar to the ISIX Methodology for Case 3 adopted in the companion *Second Report & Order*, but instead of a placement of hypothetical wireless base stations and the associated technical parameters, wireless providers would be required to use the actual technical parameters of their base stations.<sup>237</sup> We propose to require wireless providers planning co-channel or adjacent-channel operations with any television stations in the 600 MHz Band downlink spectrum to apply the OET-74 methodology using the actual location, HAAT, ERP, and antenna pattern and orientation of their base stations prior to deployment of such facilities within the specified culling

<sup>233</sup> See 47 C.F.R. § 73.616(e).

<sup>234</sup> As in the *Second Report & Order*, the term “contour” refers to either the “noise-limited contour” for full power television stations or “protected contour” for Class A television stations. See 47 C.F.R. §§ 73.622(e), 73.6010.

<sup>235</sup> A culling distance is a contour-to-site distance, whereby wireless base stations beyond this distance are culled from further analysis, because their interference contribution to DTV service within the contour would not be considered significant.

<sup>236</sup> The distances in the table were calculated based on the FCC UHF F(50,10) curves, ERP, HAAT, and an interfering field strength determined from the equation  $41 \text{ dB}\mu - 23 \text{ dB} + \text{OFR}(\text{dB})$ . The OFR values as a function of the wireless to DTV channel spectral overlap are those adopted for ISIX Case 3 and specified in Table 5 of the attached proposed OET-74. See Appendix E, Proposed OET Bulletin No. 74 at 91-93, Tables 7-13.

<sup>237</sup> As explained in the *Second Report & Order*, the impairments identified at the time of the auction will be based on the hypothetical placement of wireless base stations on a ten-by-ten kilometer grid operating with typical technical parameters. See *supra*, paras. 51-53; see also App. A, Technical Appendix at para. 16. In the *Comment PN* on final auction procedures, we will propose in more specific detail the information forward auction bidders will be provided about impairments during the auction. These impairments may be different once a wireless licensee analyzes its actual network deployment inputs.

distance of a television station's contour.<sup>238</sup> To provide wireless providers with additional flexibility, we also propose to allow them to elect to use omnidirectional patterns in their analyses rather than actual antenna patterns, either in azimuth or elevation.<sup>239</sup> We request comment on this proposal.

70. We propose to incorporate the root sum square (RSS) method into OET-74 to predict the potential for aggregate interference to a television station from multiple wireless base stations. As noted above, broadcasters raise concerns with regard to the potential for interfering LTE signals to combine at the point of DTV signal reception, resulting in additional interference.<sup>240</sup> In the *Second Report & Order*, we declined to apply the RSS method during the auction because our predictions of inter-service interference will be based on a hypothetical network deployment.<sup>241</sup> In contrast, because proposed OET-74 would be based on real-world network deployments, we believe that its accuracy would be improved by application of RSS method. Accordingly, we propose to aggregate the interfering field strength at the DTV receiver from the actual wireless base stations to be deployed post-auction using the RSS method.<sup>242</sup>

71. We propose to specify in OET-74 the same D/U and OFR ratios adopted in the *Second Report & Order* for predicting interference from wireless base stations to DTV reception during the auction.<sup>243</sup> For the reasons stated in the *Second Report & Order*, we believe the same values adopted there are appropriate to use as the thresholds for predicting interference in the post-auction environment.<sup>244</sup> We request comment on this proposal.

72. We propose to require that a 600 MHz Band wireless licensee perform an interference analysis using the methodology in OET-74 prior to deploying a base station for co-channel or adjacent-channel operations with the television stations within the set culling distance. We anticipate that wireless providers will use their own network planning software to process the OET-74 studies, but the Commission's *TVStudy* software would be made available for this purpose as well.<sup>245</sup> Before deploying a new base station or making changes to existing base stations located within the specified OET-74 culling distances for co-channel or adjacent-channel operations with a television station, a wireless licensee would have to update its interference analysis to ensure that the RSS evaluations are up-to-date and accurate. The wireless licensee would be required to retain the latest copy of its interference analysis for each co-channel or adjacent-channel Partial Economic Area (PEA) license area<sup>246</sup> where any of its base

<sup>238</sup> As the Joint Broadcasters note, the separation distances needed for the protection of broadcast television stations are affected by the technical characteristics of the stations involved, such as the transmitting height and power of the DTV stations and wireless base stations in the area. See Joint Broadcasters Comments at 30.

<sup>239</sup> See Appendix E, Proposed OET Bulletin No. 74, at 86. We note that our proposal here is distinguishable from our decision in the companion *Second Report & Order* not to impose a cap on the aggregate new interference that any one television station can receive from other stations as a result of the repacking process because the varying degrees of potential spectral overlap between television channels and wireless spectrum blocks, as well as the different technical facilities employed by television and wireless services, make predicting inter-service interference a different enterprise from predicting interference between television stations. See *supra*, para. 29.

<sup>240</sup> See, e.g., SBE Comments at 6, Joint Broadcasters Comments at 15-18.

<sup>241</sup> See *supra*, para. 55.

<sup>242</sup> See App. E, Proposed OET Bulletin No. 74 at 81, 86.

<sup>243</sup> See *supra*, paras. 42-44; see also, App. A, Technical Appendix at 62, Table 7 and 65, Table 12.

<sup>244</sup> See *supra*, paras. 42-47.

<sup>245</sup> As stated above, we will use *TVStudy* to run the ISIX calculations during the incentive auction. See *supra*, n. 78. Wireless licensees may either download *TVStudy* available at <http://data.fcc.gov/download/incentive-auctions/OET-69/> or incorporate the Longley-Rice Fortran code included with the *TVStudy* source code in their network planning software.

<sup>246</sup> See Incentive Auction R&O, 29 FCC Rcd at 6597, para. 71.

stations fall within the specified OET-74 culling distances and make the analysis available to the Commission or a subject television station upon request in cases where there are complaints of interference either from the subject television station, a station viewer or the Commission. We seek comment on these proposals.

**b. Case 4: Interference from Wireless User Equipment to Broadcast Television Stations Assigned to the 600 MHz Uplink Spectrum**

73. If broadcast television stations are assigned to channels in the 600 MHz Band uplink spectrum, we propose to restrict wireless user equipment (i.e. mobile and portable devices) operating on co-channel or adjacent-channel frequencies to areas outside the separation distances from the DTV station contours adopted in the *Second Report & Order*.<sup>247</sup> First, for co-channel operations, we propose to not to allow wireless user equipment to operate within the television station's contour and within five kilometers of that contour. Second, for adjacent channel operations, we propose to restrict user equipment operation within the contour of the television station and within one-half kilometer of that contour. We propose to limit the one-half kilometer restriction to the first-adjacent channel; thus, wireless user equipment could be operated anywhere within the contour of a broadcast television station if there is a frequency separation of six megahertz or more between the wireless spectrum block edge and a TV channel edge. We seek comment on the above proposals for protecting DTV service from harmful interference caused by wireless user equipment. Wireless providers may meet the distance requirements by limiting their coverage area to areas that are at least five kilometers if co-channel with a broadcast television station or one-half kilometer if they are adjacent channel outside the noise-limited or protected contours of the broadcast television station. Interested parties are also invited to submit suggestions for alternative approaches for providing protection to broadcast television service that would rely on methods other than pre-calculated separation distances. Parties submitting such approaches should include technical analyses and information describing how their suggested method would adequately protect broadcast television services.

**3. Proposed Obligation of Wireless Licensees to Eliminate Actual Interference to Television Stations in the 600 MHz Band**

74. While we propose to use a predictive model to prevent inter-service interference to television stations based on wireless base station deployments, we also propose to require a wireless licensee to eliminate any actual harmful interference to television service in the 600 MHz Band, even if no harmful interference is predicted. This proposed requirement will ensure that television stations assigned to the 600 MHz Band are not detrimentally affected by being co-channel or adjacent channel to wireless operations.

75. If a television station operating in the 600 MHz Band experiences harmful interference, we propose that the television station be required to contact the co-channel or adjacent-channel wireless provider thought to be causing the interference to resolve the issue. In the event of such contact, we propose to require that the wireless licensee provide the television station with the results of its OET-74 analysis demonstrating that no harmful interference was predicted to occur in the specific geographic area at issue. In the event that the parties do not reach resolution, they can submit a claim of harmful interference to the Commission. We seek comment on these proposals.

**B. Proposed Procedures to Prevent Inter-Service Interference**

**1. General Wireless Licensee Obligations**

76. Given the proposed rules set forth above, we seek comment on appropriate wireless licensee obligations, both with respect to technical requirements and service rules. Specifically, consistent with the guidance set forth in the *Incentive Auction R&O*, we propose that a 600 MHz Band

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<sup>247</sup> See *supra*, paras. 56-58.

licensee will hold a license for its entire PEA service area,<sup>248</sup> but operations will be limited to the portions of the license where the licensee will not cause harmful interference to broadcast television stations assigned to the 600 MHz Band.<sup>249</sup> Under this proposal, a wireless licensee will be allowed to operate base stations at the power and out-of-band emission (OOBE) limits authorized by our technical rules only within the areas where it can demonstrate using the proposed OET-74 methodology and inputs that it will not cause harmful interference to a television station, even if the actual boundaries of the license area extend further (i.e., it may not operate in “restricted” areas).<sup>250</sup> As we stated in the *Incentive Auction R&O*, nothing in our rules prevents a wireless provider from operating in a part of its service area in which it may *receive* interference from broadcast operations (i.e., in an “infringed” area).<sup>251</sup> We seek comment on the obligations of 600 MHz Band wireless licensees in operating in areas of their PEAs with impairments.

77. As discussed in the *Incentive Auction R&O*, 600 MHz Band wireless licensees will be required to meet the 600 MHz Band interim and final build-out requirements, except that they may show they are unable to operate in areas where they may cause harmful interference to the broadcast television stations that remain in the 600 MHz Band due to market variation. The areas where a wireless licensee may operate without causing harmful interference are the “permitted boundaries” of a license area.<sup>252</sup> If a licensee is not able to serve its entire license area, when it files its construction notification within 15 days of the relevant milestone certifying that it has met the applicable performance benchmark within its permitted boundaries,<sup>253</sup> the licensee must demonstrate why certain areas are excluded from its service area due to impairments.<sup>254</sup> We propose to require that wireless licensees use the ISIX Methodology we adopted in the *Second Report & Order* for prediction of interference in Cases 1, 2 and 4 and the methodology in proposed OET Bulletin 74 for Case 3 to demonstrate they cannot serve their entire PEA service area, among other evidence.<sup>255</sup> Further, as discussed in the *Incentive Auction R&O*, if the impairing television station ceases to operate, the wireless licensee will be permitted to use the entire

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<sup>248</sup> In the forward auction, we will offer licenses for the 600 MHz Band on a geographic area basis. The service area for these licenses will be Partial Economic Areas (“PEAs”). See *Wireless Telecommunications Bureau Provides Details About Partial Economic Areas*, GN Docket No. 12-268, Public Notice, DA 14-759 (rel. June 2, 2014) (*PEAs PN*). See 47 C.F.R. § 27.6(l).

<sup>249</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 86.

<sup>250</sup> Pursuant to existing rules regarding secondary market transactions, any party who obtains a license through a secondary market transaction is required to provide wireless services consistent with the underlying license authorization. *Incentive Auction R&O*, 22 FCC Rcd at 6891, paras. 802-803. Therefore, any entity holding an impaired license-- including entities receiving a license through secondary market transactions such as leasing; partitioning; disaggregation; merger or acquisition--must meet all applicable rules regarding impaired licenses, including protection of a Broadcast Television station (or stations) within the licensed area. *Incentive Auction R&O*, 22 FCC Rcd at 6606, para. 86.

<sup>251</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 86 n. 276.

<sup>252</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 86. This means that licensees must meet the build-out requirements only in areas in which they will not cause or receive harmful interference, using the ISIX Methodology and OET Bulletin 74.

<sup>253</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6883, para. 778; 47 C.F.R. § 1.946(d).

<sup>254</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6884, para. 781.

<sup>255</sup> For example, along with the analysis from OET Bulletin 74, the licensee would need to provide population data for the areas it can and cannot serve, with a detailed explanation of the impairment, in addition to any other relevant information to demonstrate that it has met its performance benchmarks in the permitted boundaries of its license area. *Incentive Auction R&O*, 29 FCC Rcd at 6606, 6884, paras. 86, 781.

license area, and will be obligated to serve the area that was previously restricted in demonstrating that it has met its buildout requirements.<sup>256</sup>

78. Additionally, we seek comment on any additional or modified service rules that should be applied to 600 MHz Band licensees to address the potential for inter-service interference.

## 2. Broadcasters in the 600 MHz Band

79. Consistent with the guidance in the *Incentive Auction R&O*, we propose not to permit broadcast licensees who operate in the 600 MHz Band to expand their noise-limited or protected contours if doing so would increase the potential for interference to a wireless licensee's service area.<sup>257</sup> At the same time, we tentatively conclude that broadcast television stations should be allowed to demonstrate non-interference to a wireless licensee's service area by showing that a proposed modification will not expand its contour in the direction of a co-channel or adjacent channel wireless licensee.<sup>258</sup> We believe that this approach will ensure that wireless providers that acquire spectrum through the forward auction can rely on the information available at the time of the auction as to the existence and contours of a co-channel or adjacent television station, and rely on their modeling using OET Bulletin 74 for as long as the such television station is operating. We seek comment on this proposal.

80. The contours of broadcast television stations that will be reassigned to new channels in the 600 MHz Band as a result of the repacking process will be specified in the *Channel Reassignment PN*.<sup>259</sup> In order for such stations to be able to engineer their modified facilities and quickly transition to their new channels, in the *Incentive Auction R&O* we granted them a window filing priority to propose transmission facilities in their initial construction permit applications with up to a one percent coverage contour increase if necessary to achieve the contour coverage specified in the *Channel Reassignment PN* or to address loss of coverage area resulting from their new channel assignment.<sup>260</sup> Consistent with that decision, for purposes of the proposal set forth immediately above we propose that the contours of such stations be deemed to be those described in their initial construction permit for their new channel. We believe that the impact on a wireless licensee of allowing stations reassigned to channels in the 600 MHz Band such flexibility would be negligible because a one percent increase is *de minimis*,<sup>261</sup> the increase may not be in the direction of the wireless licensee, and the initial construction applications must be filed within three months of release of the *Channel Reassignment PN*. We do not propose, however, that these stations be permitted to file for further expanded facilities on their new channels,<sup>262</sup> unless they can demonstrate that the proposed expanded facility will not increase their contour in the direction of a wireless license area. We seek comment on these proposals.

<sup>256</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 86 n. 277.

<sup>257</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6606, para. 87.

<sup>258</sup> As in the *Incentive Auction R&O*, we recognize that there may be extraordinary circumstances beyond the control of a television licensee that will result in an expansion of its contour in the direction of the wireless license area, and we will consider requests for waiver of our rules in such situation and encourage television and wireless licensees to work cooperatively to find an equitable solution. *Id.*

<sup>259</sup> Broadcast television stations that are not reassigned to new channels during the repacking process, i.e., stations that remain on their existing channels in the 600 MHz Band, will maintain their original contours. The *Channel Reassignment PN* will announce the results of the incentive auction identify the new channel assignments for full power and Class A stations that have been reassigned to different channels, and will establish the 39-month transition period. See *Incentive Auction R&O*, 29 FCC Rcd at 6782, para. 525.

<sup>260</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6791, paras. 547-48.

<sup>261</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6791, para. 548.

<sup>262</sup> See *id.* at 6793, para. 553.

### C. Predicting Inter-Service Interference During the Post-Auction Transition Period

#### 1. Predicting Interference to New 600 MHz Band Licensees from LPTV Stations and TV Translators for Notification Purposes

81. In the *Incentive Auction R&O*, we stated that during the Post-Auction Transition Period<sup>263</sup> new 600 MHz Band wireless licensees must provide LPTV and TV translator stations with advance notification that they will be displaced when the wireless licensee intends to commence operations<sup>264</sup> in areas of their licenses where there is a likelihood of receiving harmful interference from an LPTV or TV translator station, based “on the methodology we adopt to prevent inter-service interference.”<sup>265</sup> In the *Second Report & Order*, we adopted the ISIX Methodology and input values to predict interference from full power and Class A television stations to wireless services during the course of the auction.<sup>266</sup>

82. We seek comment on appropriate modifications to the ISIX Methodology to predict interference to 600 MHz Band wireless operations from LPTV and TV Translators. First, we seek comment on use of the field strength values below for predicting such interference. The interference potential of LPTV and TV Translators that have migrated their operations to digital is evaluated differently from that of full power DTV stations under our rules.<sup>267</sup> In particular, the rules specify different values for the adjacent channel emissions<sup>268</sup> and elevation patterns of low power and full power DTV stations.<sup>269</sup> We examined the effect of the different LPTV/TV translator emission masks, however, and found that the field strength thresholds of these masks and the full power television mask is no more than 1dB.<sup>270</sup> Therefore, we propose to use the same field strength values as full power television for the interference thresholds of co-channel and adjacent channel emissions for LPTV and TV translators to wireless service in the ISIX Methodology. Those thresholds, repeated in Table 2 below, are based on technical assumptions regarding the wireless receivers (both base stations and user equipment) that appear respectively in Tables 5 and 6 in the *ISIX PN*, as well as Tables 3 and 4 in the Technical Appendix below.

Spectral Overlap (MHz)	5	4	3	2	1	0	-1	-2	-3	-4	-5
LPTV Field Strength into Wireless Uplink (dBμV/m)	17.3	18.2	19.5	21.2	24.0	34.4	61.4	62.5	63.7	65.5	68.6
LPTV Field Strength into Wireless Downlink (dBμV/m)	33.8	34.7	36.0	37.6	40.4	50.7	65.8	66.6	67.6	68.9	70.8

Table 2. Interference field strength values for DTV into wireless

<sup>263</sup> The Post-Auction Transition Period is the 39-month period commencing upon the public release of the *Channel Reassignment Public Notice*. See 47 C.F.R. § 27.4.

<sup>264</sup> The Commission, however, did not define the term “commence operations” in the *Incentive Auction R&O*, instead stating that this term would be defined in the 600 MHz Band pre-auction process. See *Incentive Auction R&O* at para. 668 n.1861.

<sup>265</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6839-40, para. 668 and n.1863.

<sup>266</sup> See *supra*, paras. 36-41 (Case 1 and Case 2).

<sup>267</sup> See generally, 47 C.F.R. § 74.793.

<sup>268</sup> See 47 C.F.R. §§ 74.793(c), 74.794.

<sup>269</sup> See 47 C.F.R. § 74.793(d).

<sup>270</sup> The values for OFR were derived using the NTIA’s MSAM FDR computer program using the FCC’s emission limits, and DTV and LTE receiver performance standards published by ATSC and 3GPP, respectively. See App. A, Technical Appendix at 43, n.13.

83. In addition, we propose to use the same elevation patterns for LPTV and TV translators as those patterns appear in the Consolidated Database System (CDBS).<sup>271</sup> In the event the CDBS does not include elevation pattern values for a given low power station, we propose to use the elevation patterns of LPTV and TV translators as they are defined in section 74.793(d) of our rules.

84. In the event a potentially interfering LPTV or TV translator station is operating an analog signal, we invite comment on additional modifications to the methodology for predicting inter-service interference that may be appropriate.<sup>272</sup> One potential approach is to use *TVStudy*'s capability to "replicate" an analog signal as an equivalent digital signal and analyze the station as though it were operating in digital. We seek comment on this approach and on any other potential approaches. In the event we use the *TVStudy* approach, we seek comment on whether we should treat the interfering field strength of an analog television signal the same as an interfering digital television signal.

## 2. Wireless Operations Prior to Broadcast Television Station Relocation

85. As set forth in the *Incentive Auction R&O*, wireless providers may commence operations prior to the end of the 39-month Post-Auction Transition Period, as soon as their licensed frequencies are vacated by any full power or Class A television stations that occupied those frequencies prior to the incentive auction.<sup>273</sup> Because television stations transitioning to new channels or going off the air may be operating on different timetables under the rules established in the *Incentive Auction R&O*, there is a potential for inter-service interference between wireless providers that commence operations on frequencies that have been vacated by a broadcast television station in their license area or in part of their license area and broadcast television stations in nearby markets that have not transitioned yet.

86. Accordingly, in the event that a wireless provider seeks to commence operations prior to the end of the 39-month Post-Auction Transition Period and there are co-channel or adjacent-channel broadcast television stations in the wireless licensee's downlink spectrum within the culling distances specified in OET-74, we propose to require the wireless provider to use OET-74 to predict whether wireless operations in its license area or part of its license area will cause harmful interference to the subject television stations. The wireless licensees would be required to retain the latest copy of the OET-74 study for each co-channel or adjacent-channel PEA license area where any of their base stations fall within the specified OET-74 culling distances and make it available to the Commission and to a subject television station upon request if there are complaints of interference either from a subject television station, a member of the public or the Commission. We seek comment on these proposals.

87. If there are co-channel or adjacent channel broadcast television stations in the wireless licensee's uplink spectrum that have not cleared their pre-auction channels, we propose to require the wireless providers to ensure that their user equipment does not operate in the contours and within five kilometers of the contour when co-channel or within a half kilometer when adjacent channel. We seek comment on this proposal.

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<sup>271</sup> The Consolidated Database System (CDBS) is the Commission's database of broadcast station information. The CDBS is available at <http://www.fcc.gov/encyclopedia/media-bureau-filing-systems-and-databases>.

<sup>272</sup> The ISIX Methodology adopted in the *Second Report and Order* is designed for evaluating interference involving digital television signals, but LPTV and TV translator stations may continue operate in analog until at least September 1, 2015. The digital transition deadline for analog LPTV and TV translator stations is September 1, 2015, with the opportunity for individual stations to request a six-month extension. See *Amendment of Parts 73 and 74 of the Commission's Rules to Establish Rules for Digital Low Power Television, Television Translator, and Television Booster Stations and to Amend Rules for Digital Class A Television Stations*, MB Docket No. 03-185, Second Report and Order, 26 FCC Rcd 10732 (2011); 47 C.F.R. § 74.788(c)(3). Moreover, we recently issued a Third NPRM tentatively concluding that we should postpone this deadline. See *Amendment of Parts 73 and 74 of the Commission's Rules for Digital Low Power Television, Television Translators and Television Booster Stations*, MB Docket No. 03-185, Third Notice of Proposed Rulemaking, FCC 14-151 (rel. Oct. 10, 2014).

<sup>273</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6782, para. 525.

**D. Using the ISIX Methodology to Assess Interference from and to International Broadcast Television Stations During the Auction**

88. We have engaged in extensive discussions with Canada and Mexico to determine interference protection along the border areas. At this time, both Canada and Mexico are transitioning their broadcast services into digital in line with their regulatory requirements. Because the timing of these transitions is under the control of the administration of the respective countries, we seek comment on using the ISIX Methodology and input values to identify impairments to wireless spectrum along the international borders during the auction.<sup>274</sup>

89. As noted above, the ISIX Methodology adopted in the companion *Second Report & Order* item is not designed for analog signals. As Canada and Mexico have not completed their digital transitions, we also seek comment on implementing an approach similar to that proposed above for predicting interference from analog LPTV to wireless service.<sup>275</sup> Specifically, in predicting interference to and from foreign analog broadcast television stations along our international borders, we propose to use *TVStudy*'s capability to "replicate" an analog signal as an equivalent digital signal and analyze the station as though it was operating as digital.

**IV. PROCEDURAL MATTERS**

**A. Final and Initial Regulatory Flexibility Analysis**

90. As required by § 603 of the Regulatory Flexibility Act of 1980 (RFA), 5 U.S.C. § 603, the Commission has prepared a Final Regulatory Flexibility Analysis of the possible economic impact on small entities of the policies and rules adopted in this *Second Report and Order*. This Final Regulatory Flexibility Analysis is set forth in Appendix F.

91. As required by the RFA, the Commission has prepared an Initial Regulatory Flexibility Analysis ("IRFA") relating to this *NPRM*. The IRFA is attached to this *NPRM* as Appendix G.

**B. Final and Initial Paperwork Reduction Act Analysis**

92. This *Second Report and Order* contains modified information collection requirements subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13. It will be submitted to the Office of Management and Budget (OMB) for review under Section 3507(d) of the PRA. OMB, the general public, and other federal agencies are invited to comment on the modified information collection requirements contained in this proceeding. In addition, we note that pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, *see* 44 U.S.C. 3506(c)(4), we previously sought specific comment on how the Commission might further reduce the information collection burden for small business concerns with fewer than 25 employees.

93. We have assessed the effects of the policies adopted in this *Second Report & Order* with regard to information collection burdens on small business concerns, and find that these policies will benefit companies with fewer than 25 employees by providing them with a safeguard in the unlikely event of aggregate new interference in excess of one percent. In addition, we have described impacts that might affect small businesses, which includes most businesses with fewer than 25 employees, in the FRFA attached to this *Second Report & Order* as Appendix F.

94. This *FNPRM* contains proposed information collection requirements. The Commission, as part of its continuing effort to reduce paperwork burdens, invites the general public and the Office of Management and Budget (OMB) to comment on the information collection requirements contained in this document, as required by the Paperwork Reduction Act of 1995, Public Law 104-13. In addition, pursuant

<sup>274</sup> Post-auction protection of international broadcasters and wireless operations along the border are subject to the bilateral agreements with Canada and Mexico.

<sup>275</sup> *See supra*, para. 81-84.

to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, *see* 44 U.S.C. 3506(c)(4), we seek specific comment on how we might further reduce the information collection burden for small business concerns with fewer than 25 employees.

### C. Filing Requirements

95. Pursuant to sections 1.415 and 1.419 of the Commission's rules 47 CFR §§ 1.415, 1.419, interested parties may file comments and reply comments on or before the dates indicated on the first page of this document. Comments may be filed using the Commission's Electronic Comment Filing System (ECFS). *See Electronic Filing of Documents in Rulemaking Proceedings*, 63 FR 24121 (1998).

- Electronic Filers: Comments may be filed electronically using the Internet by accessing the ECFS: <http://fjallfoss.fcc.gov/ecfs2/>.
- Paper Filers: Parties who choose to file by paper must file an original and one copy of each filing. Parties filing comments and/or replies in response to the *Further Notice of Proposed Rulemaking* must file their documents in ET Docket No. 14-14, 13-26 and GN Docket No. 12-68.
- Filings can be sent by hand or messenger delivery, by commercial overnight courier, or by first-class or overnight U.S. Postal Service mail. All filings must be addressed to the Commission's Secretary, Office of the Secretary, Federal Communications Commission.
  - All hand-delivered or messenger-delivered paper filings for the Commission's Secretary must be delivered to FCC Headquarters at 445 12<sup>th</sup> St., SW, Room TW-A325, Washington, DC 20554. The filing hours are 8:00 a.m. to 7:00 p.m. All hand deliveries must be held together with rubber bands or fasteners. Any envelopes and boxes must be disposed of before entering the building.
  - Commercial overnight mail (other than U.S. Postal Service Express Mail and Priority Mail) must be sent to 9300 East Hampton Drive, Capitol Heights, MD 20743.
  - U.S. Postal Service first-class, Express, and Priority mail must be addressed to 445 12<sup>th</sup> Street, SW, Washington DC 20554.

People with Disabilities: To request materials in accessible formats for people with disabilities (braille, large print, electronic files, audio format), send an e-mail to [fcc504@fcc.gov](mailto:fcc504@fcc.gov) or call the Consumer & Governmental Affairs Bureau at (202) 418-0530 (voice), (202) 418-0432 (tty).

### D. Ex Parte Rules

96. The proceeding this Notice initiates shall be treated as a "permit-but-disclose" proceeding in accordance with the Commission's *ex parte* rules.<sup>276</sup> Persons making *ex parte* presentations must file a copy of any written presentation or a memorandum summarizing any oral presentation within two business days after the presentation (unless a different deadline applicable to the Sunshine period applies). Persons making oral *ex parte* presentations are reminded that memoranda summarizing the presentation must (1) list all persons attending or otherwise participating in the meeting at which the *ex parte* presentation was made, and (2) summarize all data presented and arguments made during the presentation. If the presentation consisted in whole or in part of the presentation of data or arguments already reflected in the presenter's written comments, memoranda or other filings in the proceeding, the presenter may provide citations to such data or arguments in his or her prior comments, memoranda, or other filings (specifying the relevant page and/or paragraph numbers where such data or arguments can be found) in lieu of summarizing them in the memorandum. Documents shown or given to Commission staff during *ex parte* meetings are deemed to be written *ex parte* presentations and must be filed consistent with rule 1.1206(b). In proceedings governed by rule 1.49(f) or for which the Commission has made available a method of electronic filing, written *ex parte* presentations and memoranda summarizing

<sup>276</sup> 47 C.F.R. §§ 1.1200 *et seq.*

oral *ex parte* presentations, and all attachments thereto, must be filed through the electronic comment filing system available for that proceeding, and must be filed in their native format (e.g., .doc, .xml, .ppt, searchable .pdf). Participants in this proceeding should familiarize themselves with the Commission's *ex parte* rules.

**E. Congressional Review Act**

97. The Commission will send a copy of the *Second Report and Order* to Congress and the Government Accountability Office pursuant to the Congressional Review Act.<sup>277</sup>

**F. Further Information**

98. For additional information, please contact Aspasia Paroutsas, Office of Engineering and Technology, at (202) 418-7285 or [Aspasia.Paroutsas@fcc.gov](mailto:Aspasia.Paroutsas@fcc.gov).

**V. ORDERING CLAUSES**

99. **IT IS ORDERED**, pursuant to the authority found in Sections 1, 4, 301, 303, 307, 308, 309, 310, 316, 319, 332, and 403 of the Communications Act of 1934, as amended, and sections 6004, 6402, 6403, 6404, and 6407 of Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, 126 Stat. 156, 47 U.S.C. §§ 151, 154, 301, 303, 307, 308, 309, 310, 316, 319, 332, 4031404, 1452, and 1454, and section 1.2 of the Commission's rules, 47 C.F.R. § 1.2, the *Second Report and Order*, *Further Notice of Proposed Rule Making* **IS ADOPTED. IT IS FURTHER ORDERED** that the Commission's rules **ARE HEREBY AMENDED** as set forth in Appendix B.

100. **IT IS FURTHER ORDERED** that the rules adopted herein **WILL BECOME EFFECTIVE** 30 days after the date of publication in the *Federal Register*, except for Sections 73.3700(b)(1)(iv)(B), 73.3700(b)(2)(i), and 73.3700(b)(2)(ii) of the rules which contain new or modified information collection requirements subject to the Paperwork Reduction Act of 1995, Public Law 104-13, that are not effective until approved by the Office of Management and Budget (OMB). The Federal Communications Commission will publish a document in the Federal Register announcing OMB approval and the effective date of this rule.

101. **IT IS FURTHER ORDERED** that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, **SHALL SEND** a copy of this *Second Report and Order* in GN Docket No. 12-268, including the Final Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

102. **IT IS FURTHER ORDERED** that the Commission **SHALL SEND** a copy of this *Second Report and Order* in GN Docket No. 12-268 in a report to be sent to Congress and the Government Accountability Office pursuant to the Congressional Review Act, *see* 5 U.S.C. § 801(a)(1)(A).

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<sup>277</sup> *See* 5 U.S.C. § 801(a)(1)(A).

103. **IT IS FURTHER ORDERED** that the Commission's Consumer and Governmental Affairs Bureau, Reference Information Center, **SHALL SEND** a copy of this *Further Notice of Proposed Rulemaking* in GN Docket No. 12-268, including the Initial Regulatory Flexibility Analysis, to the Chief Counsel for Advocacy of the Small Business Administration.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch  
Secretary

## APPENDIX A

**TECHNICAL APPENDIX:  
METHODOLOGY FOR IDENTIFYING IMPAIRED LOCATIONS  
IN 600 MHz WIRELESS LICENSE AREAS DURING THE  
BROADCAST TELEVISION INCENTIVE AUCTION**

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**I. INTRODUCTION**

1. This appendix sets forth a methodology for predicting interference between broadcast television and wireless services when co-channel or adjacent-channel to the 600 MHz Band (“ISIX Methodology”). The ISIX Methodology will be used to identify the locations within a wireless 600 MHz Band license area that either experience interference from DTV or cause interference to DTV.

2. The ISIX methodology uses the NTIA Institute of Telecommunications Science’s Irregular Terrain Model (Longley-Rice model) for predicting radio signal propagation losses, established planning factors and industry standards to define thresholds of coverage and interference, and typical technical specifications in the absence of industry standards. It also generally applies commonly used protocols, databases, and propagation models to describe a predictive methodology that can be run on a computer. For broadcast television, it assumes use of the Advanced Television Systems Committee’s (ATSC) Digital Television (DTV) Standard,<sup>1</sup> although it is possible, especially across international borders, that the National Television Systems Committee (NTSC) analog Television (TV) standard may also be used.<sup>2</sup> For wireless operations, it assumes use of the 3<sup>rd</sup> Generation Partnership Project (3GPP)

<sup>1</sup> See 47 C.F.R. § 73.682(d).

<sup>2</sup> For analog NTSC television transmission standards, *see, e.g.*, 28 FR 13676. Domestically, low-power television stations, including Class A and television translators, are the only remaining over-the-air broadcast television service permitted to transmit analog signals. However, these stations will be required to cease analog operation and convert to digital operation (currently by September 1, 2015). *See* Amendment of Parts 73 and 74 of the Commission’s Rules to Establish Rules for Digital Low Power Television, Television Translator, and Television Booster Stations and to Amend Rules for Digital Class A Television Stations, *Second Report and Order*, 26 FCC Rcd 10732 (2011).

Long-Term Evolution (LTE) standard.<sup>3</sup>

3. The ISIX Methodology uses the Longley-Rice radio propagation model, which predicts field strength at receive points based on the elevation profile of terrain between the transmitter and each specific reception point.<sup>4</sup> Predictions are made over a large area (described as a 2-kilometer global grid of calculation cells).<sup>5</sup> Predictions of interference for the purpose of determining impairment locations during the incentive auction will be made using the FCC's *TVStudy* software and relevant TV station engineering data from the FCC's Consolidated Database System (CDBS).<sup>6</sup>

## II. OVERVIEW OF METHODOLOGY

4. To determine potential wireless license impairments, we first define the area subject to calculation. For interference to wireless, the area subject to calculation is defined as each wireless Partial Economic Area (PEA).<sup>7</sup> For interference to TV, the area subject to calculation is the area inside of the noise-limited contour defined in 47 C.F.R. § 73.625(a) for full-power DTV stations and the area within the protected contour defined in 47 C.F.R. § 73.6010 for digital Class A TV stations.<sup>8</sup>

5. There are four scenarios, or cases, of potential interference that may be experienced as a result of market variation. When broadcast television operations and wireless operations are co-channel

<sup>3</sup> Specifically, we reference the radio access layer of the 3GPP LTE technical specification, Release 10. See Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception, 3GPP specification detail, <http://www.3gpp.org/DynaReport/36104.htm>, Version 10.11.0. See also Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception, 3GPP specification detail, <http://www.3gpp.org/DynaReport/36101.htm>, Version 10.12.0.

<sup>4</sup> Version 1.2.2 of the National Telecommunications and Information Administration (NTIA) Institute for Telecommunication Sciences (ITS) Irregular Terrain Model (ITM), known as the Longley-Rice model after Anita Longley and Phil Rice who developed the original version of the model, is available at <http://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx>. The source code for this version of the Longley-Rice model, used by the Commission in several other contexts including OET Bulletin Nos. 69, 72 and 73, is available in FORTRAN, C++, and in algorithm form at the website cited above.

<sup>5</sup> See *TVStudy Manual* at [http://data.fcc.gov/download/incentive-auctions/OET-69/2014Apr\\_TVStudyManual.pdf](http://data.fcc.gov/download/incentive-auctions/OET-69/2014Apr_TVStudyManual.pdf). The latitude size of cells is fixed for any grid type based on the specified cell size, but for a global grid the longitude size varies in steps according to latitude range (up to 75 degrees latitude). Breaks in latitude bands defining the northern and southern edges of cells are targeted to occur when the cell area changes by 2% across a band. However, incrementing the integer longitude size by a whole number of seconds will lead to an actual area change by more than 2%. For a 2-kilometer target cell size, the change in area is actually 3.25%, meaning the area of cells varies from 4.07 km<sup>2</sup> at the south edge to 3.94 km<sup>2</sup> at the north edge of a band. The actual area of each cell is to be used when cell areas are summed to determine a contour or service areas, so the changes in cell areas across a grid latitude band do not result in cumulative summation errors. Cells are referenced by their southeast corner, beginning with zero degrees latitude, zero degrees longitude.

<sup>6</sup> The FCC's *TVStudy* software provides analysis of coverage and interference of full-service digital and Class A television stations, with enhanced features and user functionality from previous versions of software implementing the Longley-Rice model. The FCC is using its *TVStudy* software in connection with the proposed broadcast television spectrum incentive auction. See <http://www.fcc.gov/document/oet-announces-release-updated-oet-69-software>. The Longley-Rice Fortran code implementing the Longley-Rice model is used in the FCC's *TVStudy* software. As the Longley-Rice Fortran code is complex, many of its options are configurable through the FCC's *TVStudy* software, available for download at <http://data.fcc.gov/download/incentive-auctions/OET-69/>. Parties installing this software should have computer programming skills and experience as a system administrator of the computer system on which it is to be installed.

<sup>7</sup> There are 416 PEAs that will be licensed. Each PEA is comprised by one or more US counties. See <http://transition.fcc.gov/oet/info/maps/areas/>

<sup>8</sup> The term "contour", unless otherwise noted, refers to either the noise-limited or protected contour of a full-power or Class A TV station, respectively.

or adjacent-channel in nearby markets, interference may be predicted in the following four cases: (1) DTV transmitter-into-wireless base station; (2) DTV transmitter into wireless user equipment; (3) Wireless base station-into-DTV receivers; and (4) Wireless user equipment-into-DTV receivers. These cases are shown graphically in Figure 1 below:

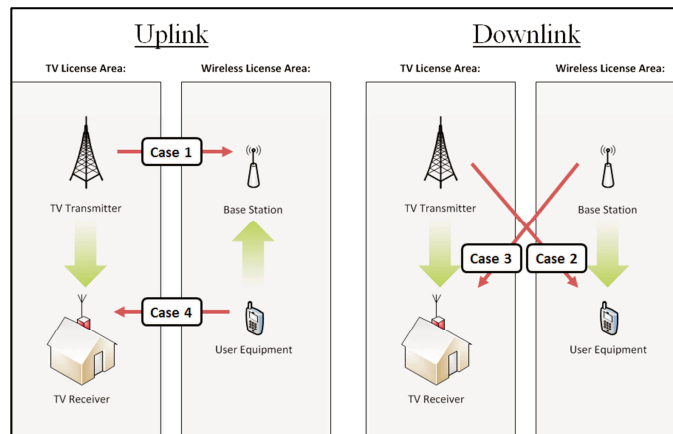


Figure 1. Four interference scenarios

6. Depending on the interference scenario being examined, the methodology evaluates interference using either field strength limits at the wireless receive antenna, or D/U ratios at the DTV receive antenna, as a function of the amount of spectral overlap between the DTV and wireless channel. Potential interference is then defined to occur at a specified location when the predicted interfering field strength or D/U ratio fails to meet the applicable threshold. Locations where interference occurs to or originates from the wireless network are collectively the impaired locations which will be used as a basis for determination of impairments within each wireless license area during the auction.

7. Because the near-national band plan will not be known until the level of broadcaster participation in the auction is determined, the alignment of the wireless blocks to repacked DTV stations who are assigned channels in the repurposed 600 MHz spectrum is also unknown. For this reason, all interference thresholds are specified in terms of spectral overlap. Spectral overlap refers to the degree of wireless spectrum block to TV channel overlap and is an integer number between +5 MHz and -5 MHz, in 1 MHz increments. When the wireless block completely overlaps the TV channel the spectral overlap is equal to +5 MHz, and when there is 5 MHz of separation between the wireless block edge and the TV channel the spectral overlap is equal to -5 MHz. Co-channel interference refers to the instances when the wireless block overlaps the TV channel by 5 to 1 MHz (spectral overlap = +5 to 1 MHz) and adjacent-channel interference refers to instances when the wireless block edge and TV channel edge are separated by 0 to 5 MHz (spectral overlap = 0 MHz to -5 MHz).

### III. PREDICTING INTERFERENCE FROM DTV TO WIRELESS (CASES 1 AND 2)

8. Cases 1 and 2 involve interference caused by a co- or adjacent-channel DTV transmitter to a wireless base station (BS) or user equipment (UE), respectively. To determine areas of possible interference to wireless (wireless service impairments, or “infringed” portions of a wireless license area) we divide the wireless license area into a 2-kilometer global grid and calculate field strength levels at the population centroid of each grid point for each DTV facility within approximately 500 km of the wireless license boundary.<sup>9</sup> Every DTV station is replicated onto channel 38<sup>10</sup> and the predicted F(50,50) field

<sup>9</sup> *TVStudy* only calculates field strength within a DTV station’s service contour, therefore for Cases 1 or 2 we set the service contour threshold to 0 dBμV/m, use the F(50,10) curves and a minimum HAAT of 50 meters to achieve the largest calculation area possible. This generally equates to a maximum distance of about 500 km but varies based (continued....)

strength<sup>11</sup> at each grid point is then compared to the appropriate interference field strength threshold for each spectral overlap. Since we cannot consider actual 600 MHz wireless deployments, all field strength thresholds for Cases 1 and 2 are based on the assumption that the desired wireless signal is always at the edge of coverage and operating at or near the receiver sensitivity threshold. Additionally, the wireless base station receiver assumptions do not consider antenna discrimination or other techniques to mitigate interference. Thus, impaired locations due to either Case 1 or Case 2 tend to be conservatively large.

9. Figure 2 illustrates how the spectral overlaps and field strength thresholds are used during the auction to identify impaired locations within each wireless market.

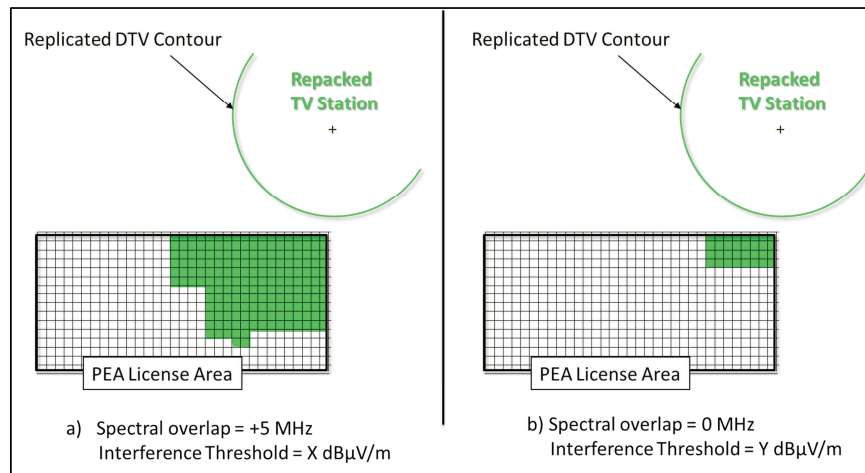


Figure 2. Illustration of interference prediction from DTV to wireless license area

10. Figure 2a shows the impaired locations within the PEA license area if the spectral overlap between the wireless channel and TV channel were +5 MHz. The green grid cells in Figure 2a are the locations where the predicted field strength from the DTV station exceeds the interference threshold, X.

(Continued from previous page)

on the terrain near the DTV facility (contours only consider terrain elevations between 2 and 10 miles from the DTV facility), and DTV facility parameters, such as ERP and HAAT.

<sup>10</sup> Channel 38 is selected as the proxy channel because it is approximately in the middle of where a repacked DTV station may potentially be in the 600 MHz Band. This channel will be used in estimating the contours of DTV stations when determining impairments to wireless licenses. We note that the use of a proxy channel in this ISIX methodology differs from the approach adopted by the Commission in the Incentive Auction R&O for determining TV-to-TV interference, where the coverage area and interference between stations is calculated on every possible channel that could be assigned during the repacking process. See *Incentive Auction R&O*, 29 FCC Rcd at 6620, para. 115. A different approach is used in the ISIX Methodology for two reasons. Any potential improvement in the accuracy of estimating wireless license impairments obtained by using actual channels would be limited by the fact that we are calculating interference in Cases 1 and 2 with the assumption that the wireless base station or user equipment is operating at or near receiver sensitivity (non-optimal configurations) and in Case 3 we are using hypothetical base station locations and configurations. Second, as noted above, the *Comment PN* will address how we define categories of fungible wireless licenses, and it is likely that the impairment calculations will require some level of aggregation to limit the number of license categories offered in the forward auction. However, we propose to use actual channels for post-auction interference predictions as described in the FNPRM. Once the final channel assignments are determined post-auction, using actual channels will be feasible because the specific DTV station and the location and configurations of the actual (as opposed to hypothetical) base stations will be known.

<sup>11</sup> All field strength predictions for Cases 1 or 2 are median situations which means that Longley-Rice statistical parameters are set for median situations (50% confidence), for 50% of the locations, 50% of the time (i.e. F(50,50))

Similarly, Figure 2b shows the impaired locations within the same PEA license area if the spectral overlap were 0 MHz. The green grid cells in Figure 2b show the locations where the predicted field strength from the DTV station exceeds the interference threshold, Y. For Case 1 or Case 2, this interference would occur in a base station receiver or UE receiver, respectively, and the field strength limit is derived accordingly considering typical assumptions in either case. These calculations are performed for each DTV station and each spectral overlap value to develop a complete list of Case 1 or 2 impairment locations for use during the incentive auction.

**A. Threshold Values for Interference from Digital Full-Power and Class A TV Stations into Wireless Uplink (Case 1)**

11. The field strength interference limits for interference from full-power DTV and digital Class A sources into the wireless uplink (base station receive) are shown in Table 1.

Spectral Overlap (MHz)	5	4	3	2	1	0	-1	-2	-3	-4	-5
DTV into Wireless Uplink (dBμV/m)	17.3	18.2	19.5	21.2	24.0	34.4	61.4	62.5	63.7	65.5	68.6

Table 1. Interference field strength values for DTV into wireless uplink

The assumptions for typical base station height, antenna pattern, antenna gain and receiver sensitivity used to determine these limits are provided in Table 3 below.

**B. Threshold Values for Interference from Digital Full-Power and Class A TV Stations into Wireless Downlink (Case 2)**

12. The field strength interference limits for interference from full-power DTV and digital Class A sources into the wireless downlink (UE receive) as shown in Table 2.

Spectral Overlap (MHz)	5	4	3	2	1	0	-1	-2	-3	-4	-5
DTV into Wireless Downlink (dBμV/m)	33.8	34.7	36.0	37.6	40.4	50.7	65.8	66.6	67.6	68.9	70.8

Table 2. Interference field strength values for DTV into wireless downlink

Table 4 below provides details on the assumptions for typical user equipment height, antenna pattern, antenna gain and receiver sensitivity used to determine these limits.

**C. Technical Specifications**

13. *Field Strength Limits for DTV Interference to Wireless.* The values shown in Table 1 and Table 2 are derived from the technical specifications and assumptions given in Table 3, Table 4, and Table 5 and using the formula below.

$$\text{Field Strength Limit (dB}\mu\text{V/m)} = P_{\text{REFSENS}} - K_d - G + L + \text{OTR} + \text{OFR}$$

Where:

$P_{\text{REFSENS}}$ (dBm)	= victim receiver reference sensitivity level
$K_d$ (dBm-dBμV/m)	= dipole factor at 615 MHz <sup>12</sup>
G (dBd)	= antenna gain
L (dB)	= line loss
OTR (dB)	= receiver on-tune rejection (dB)
OFR (dB)	= off-frequency rejection (dB) as a function of spectral overlap

<sup>12</sup> See OET Bulletin No. 69, Table 3. The adjustment,  $K_a = 20 \log[615/(\text{channel mid-frequency in MHz})]$ , is added to  $K_d$  to account for the fact that field strength requirements are greater for UHF channels above the geometric mean frequency of the UHF band and smaller for UHF channels below that frequency. The geometric mean frequency, 615 MHz, is approximately the mid-frequency of channel 38.

Parameter	Value	Comment
$P_{\text{REFSENS}}$ (dBm)	-101.5	Reference sensitivity level, per 3GPP Technical Specification 36.104 § 7.2.
$K_d$ (dBm-dBμV/m)	-130.8	Dipole Factor, OET Bulletin No. 69, Table 3.
$G$ (dBd)	13.8	$G$ (dBd) = 12.8 dBd + $G_{\text{div}}$ - $G_{\text{horiz}}$ . $G_{\text{div}}$ is receive antenna diversity gain, assumed to be 3 dB, and $G_{\text{horiz}}$ is additional antenna discrimination due to downtilt below the radio horizon, assumed to be 2 dB.
Antenna Pattern	Non-directional	
$L$ (dB)	1	Assumed line loss.
Receiver BW (MHz)	5	For bandwidths (BW) $\geq 5$ MHz, the reference sensitivity level is measured in accord with the 3GPP Technical Specification 36.104 using 25 consecutive resource blocks, corresponding to a channel bandwidth of 4.5 MHz.
Thermal noise, $N_t$ (dBm)	-107.5	= -174 (dBm/Hz) + $10\log_{10}(4.5 \text{ MHz})$ .
Effective noise figure, $N_e$ (dB)	6	
OTR (dB)	0.8	For TV into wireless, $\text{OTR} = 10\log_{10}(6/5) = 0.8$ dB. Using typical 3 dB transmit signal bandwidths, $10\log_{10}(5.38/4.5)$ is also approximately 0.8 dB.
OFR (dB)	Varies	See Table 5
HG(2) (m AGL)	30	Assumed receive antenna height for wireless base stations.

Table 3. Wireless base station receiver technical parameters

Parameter	Value	Comment
$P_{\text{REFSENS}}$ (dBm)	-100	Reference sensitivity level, per 3GPP Technical Specification 36.101 § 7.3.
$K_d$ (dBm-dBμV/m)	-130.8	Dipole Factor, OET Bulletin No. 69, Table 3.
$G$ (dBd)	-2.2	Assumes 0 dBi - 2.2 (approximate dipole gain).
Antenna Pattern	Non-directional	
$L$ (dB)	0	Assumed line loss.
Receiver BW (MHz)	5	For bandwidths (BW) $\geq 5$ MHz, the reference sensitivity level is measured in accord with the 3GPP Technical Specification 36.104 using 25 consecutive resource blocks, corresponding to a channel bandwidth of 4.5 MHz.
Thermal noise, $N_t$ (dBm)	-107.5	= -174 (dBm/Hz) + $10\log_{10}(4.5 \text{ MHz})$ .
Effective noise figure, $N_e$ (dB)	7.5	
OTR (dB)	0.8	For TV into wireless, $\text{OTR} = 10\log_{10}(6/5) = 0.8$ dB. Using typical 3 dB transmit signal bandwidths, $10\log_{10}(5.38/4.5)$ is also approximately 0.8 dB.
OFR (dB)	Varies	See Table 5
HG(2) (m AGL)	1.5	Assume 1.5 m height for user equipment receiver.

Table 4. Wireless user equipment receiver technical parameters

The values of OFR were derived using NTIA's MSAM FDR computer program,<sup>13</sup> with FCC's emission limits for 600 MHz wireless,<sup>14</sup> and DTV receiver performance standards published by ATSC.<sup>15</sup> The results are provided in Table 5.

Overlap in MHz OFR (dB)	5	4	3	2	1	0	-1	-2	-3	-4	-5
DTV into Wireless Uplink	0	0.9	2.2	3.9	6.7	17.1	44.1	45.2	46.4	48.2	51.3
DTV into Wireless Downlink	0	0.9	2.2	3.8	6.6	16.9	32	32.8	33.8	35.1	37

Table 5. Calculated off-frequency rejection (OFR) values for DTV into wireless

14. The values set in the Longley-Rice Fortran code implementing the Longley-Rice model accompanying the FCC's *TVStudy* software are provided in Table 6 below. As adopted in the *Second Report & Order*, we use F(50,50) propagation for Cases 1 and 2 and in those cases where error code 3 occurs (KWX = 3), the predicted field strength is to be accepted as indicative of the interfering field strength at that location.<sup>16</sup>

<sup>13</sup> The International Telecommunications Union (ITU) has accepted frequency-dependent rejection (FDR) as an established technique in measuring the combination of receiver selectivity and unwanted transmitter emissions for calculating distance and frequency separations at acceptable interference levels in its publication ITU-R SM.337-6 (2008), available at: [http://www.itu.int/dms\\_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf](http://www.itu.int/dms_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf). National Telecommunications and Information Administration (NTIA)'s FDR is a computer-based implementation of this widely-accepted method available in its Microcomputer Spectrum Analysis Models (MSAM) software suite. See, e.g., Communications Receiver Performance Degradation Handbook, <http://www.ntia.doc.gov/files/ntia/publications/jsc-cr-10-004final.pdf> at 28-31 (last visited Apr. 17, 2014); NTIA Technical Memo TM-09-461 (<http://www.its.bldrdoc.gov/publications/2498.aspx>) at 5-8, 5-9 (last visited Apr. 17, 2014); Frequency Dependent Rejection (FDR) Overview, <http://ntiacsd.ntia.doc.gov/msam/FDR/FDRoverview.htm> (last visited Apr. 17, 2014).

<sup>14</sup> See 47 C.F.R. §§ 27.53(g) and 73.623(h).

<sup>15</sup> See ATSC Recommended Practice A/74: Receiver Performance Guidelines, section 5.4.2, Adjacent Channel Rejection, 7 Apr. 2010, available at [http://www.atsc.org/cms/standards/a\\_74-2010.pdf](http://www.atsc.org/cms/standards/a_74-2010.pdf) (last visited May 1, 2014).

<sup>16</sup> See *supra*, *Second Report & Order*, para. 54.

Parameter	Value	Meaning/Comment
EPS	15.0	Relative permittivity of ground.
SGM (S/m)	0.005	Ground conductivity.
ZSYS	0.0	General System Elevation. Coordinated with setting of EN0.
EN0 (ppm)	301.0	Surface refractivity in N-units.
IPOL	0	Denotes horizontal polarization.
MDVAR	3	Calculation Mode (Broadcast).
KLIM	5	Climate Code (Continental Temperate).
XI (km)	0.1	Terrain sampling interval.
HG(1) (m)	See note	Height of the radiation center above ground.
HG(2) (m)	30	Height of hypothetical base station antenna above ground (Table 3).
	1.5	Height of hypothetical user equipment above ground (Table 4).
Time variability	50%	
Location variability	50%	
Confidence variability	50%	(Also called situational variability)
Error Flag	Ignore	Accept pathloss value that is returned by Longley-Rice code
<p><b>Note 1.</b> HG(1) is the height of the transmitting antenna radiation center above ground. For TV, it is determined by subtracting the ground elevation above mean sea level (AMSL) at the transmitter location from the height of the radiation center AMSL. The latter value is contained in the FCC's CDBS, and may be found by query at <a href="http://www.fcc.gov/mb/video/tvq.html">http://www.fcc.gov/mb/video/tvq.html</a>. The former is retrieved from the terrain elevation database as a function of the transmitter site coordinates also found in CDBS. Bilinear interpolation between the surrounding data points in the terrain database is used to determine the ground elevation. Care should be used to ensure that consistent horizontal and vertical datums are employed among all data sets.</p>		

Table 6. Longley-Rice parameter values for ISIX Cases 1 and 2

#### IV. **PREDICTING INTERFERENCE FROM WIRELESS TO DTV (CASES 3 AND 4)**

15. Cases 3 and 4 involve interference caused by a co- or adjacent-channel base station or UE transmitter to a DTV receiver, respectively. Evaluations of interference from wireless base stations to DTV stations (Case 3) are to be performed during the broadcast television incentive auction using a methodology that examines the desired-to-undesired (D/U) field strength ratio between a desired DTV transmitter and a series of uniformly distributed hypothetical base station transmitters operating with typical parameters. Case 3 impaired locations ("restricted" portions of a wireless license area) are then defined by the county boundaries<sup>17</sup> from within which at least one hypothetical base station transmitter is predicted to cause interference based on specified D/U threshold values. In the case of UE interference to DTV receivers (Case 4) impaired locations are defined by the collection of all the 2-kilometer grid points that fall inside the DTV station's protected contour or noise-limited contour and within a specified separation distance outside the DTV station's contour.

<sup>17</sup> We use the county boundary files from the 2010 US Census available at <ftp://ftp2.census.gov/geo/tiger/TIGER2010/COUNTY/2010/>

16. Case 3. The DTV station is replicated onto TV channel 38<sup>18</sup> and its contour is calculated. The area within DTV station's contour is then divided into 2-kilometer grid cells and the desired DTV field strength at the population centroid of the grid cell is calculated. In cases where the grid cell does not contain population, the geometric center of the grid cell is selected as the calculation point. To calculate the undesired field strength, we sample the surrounding license areas by placing uniformly spaced hypothetical wireless base stations every 10 kilometers<sup>19</sup> with transmitting antennas at 30 meters above average terrain.<sup>20</sup> Each hypothetical base station is set up to transmit on the TV channel 38 center frequency. We limit the number of hypothetical base stations considered to those that fall within 500 kilometers of the DTV facility.

17. The undesired field strength from each hypothetical base station within 300 kilometers of a 2-kilometer grid cell is then predicted and a D/U ratio is determined. The interference analysis for TV reception examines only those cells across the global 2-kilometer grid that have already been determined to have a desired field above the field strength threshold for DTV reception given in Table 9 or Table 10, as appropriate. A cell on the global 2-kilometer grid is counted as receiving interference to TV if the ratio of the desired field strength to that of any one of the possible undesired wireless interference sources is less than the applicable threshold value specified in Table 7. The comparison is made after the discrimination effect of the receiving TV antenna is applied to the undesired field strength for a given cell. The assumed parameters of the hypothetical base stations are provided in Table 13.

18. Each grid point inside the DTV station's contour where the predicted D/U ratio falls below the appropriate threshold value is noted along with the corresponding hypothetical base station location causing the predicted interference. All county areas corresponding with a 10-kilometer grid area from which a hypothetical base station causes interference to DTV service are then noted as impaired locations, resulting in restrictions in wireless license areas.

19. Figure 3 illustrates how the how spectral overlaps and D/U threshold values are to be used for a Case 3 ISIX analysis. In the figure, the sample locations of the hypothetical base stations are shown as "+". The hypothetical base stations that cause interference to any 2-kilometer grid cell within the repacked TV station's contour are shown as  $\oplus$ .

<sup>18</sup> Because impaired locations are a result of TV stations in the 600 MHz Band, we can assume that the TV channel for which we want to predict wireless license impairments is at least above TV channel 26, which corresponds with the largest clearing target in the *Incentive Auctions R&O*. See *Incentive Auctions R&O*, 29 FCC Rcd at 7018, App. C, Technical Appendix. Impaired locations could be anywhere in the re-purposed wireless spectrum, especially with respect to cases caused by international TV stations. We will use TV channel 38 to replicate all DTV stations for purposes of estimating their contours after repacking and potential wireless license impairments during the auction. However, we propose to use actual TV channels for post-auction interference prediction, as described in the FNPRM. See *supra*, FNPRM at para. 69.

<sup>19</sup> The 3GPP LTE standard supports a maximum cell radius of 100 kilometers. In practice, however, cell radii vary from fraction of a kilometer in dense urban environments to tens of kilometers in sparsely populated rural areas. See Commerce Spectrum Management Advisory Committee (CSMAC), Final Report, Working Group 1 – 1695-1710 MHz Meteorological-Satellite, Rev. 1, July 23, 2013, Appendix 3. The uniform 10-kilometer spacing for base station transmitting sites we describe in this appendix approaches a practical limit on computation. The area surrounding each 10-kilometer base station can be thought of as a square with dimensions approximately 10 kilometers on each side, for a total area of 100 square kilometers associated with each hypothetical wireless site.

<sup>20</sup> The antenna height above average terrain (HAAT) is determined by the average elevation of between 3.2-16.1 kilometers (2-10 miles) from an antenna site for 8 radials at each 45 degrees of azimuth starting with the True North, using a terrain sampling interval of 0.1 kilometer along each radial.

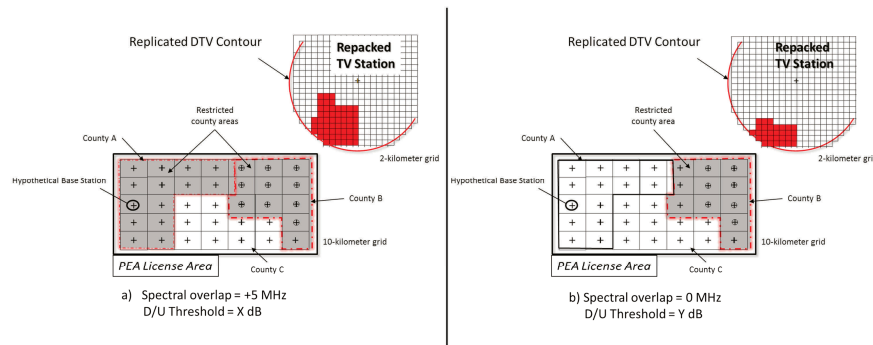


Figure 3. Illustration of Case 3 Impaired Locations (restricted operating areas)

20. Interference is considered to occur at 2-kilometer grid points where the calculated D/U ratio from any hypothetical base station exceeds the specified limit based on spectral overlap. Figure 3a shows several hypothetical base stations as causing interference (shown as “⊕”) to at least one 2-kilometer grid cell of the repacked TV station based on a spectral overlap of +5 MHz and a corresponding D/U threshold of X dB. County areas A and B are both marked as impaired locations within the PEA license area because their areas both intersect with at least one 10-kilometer grid area containing an interference causing hypothetical base station. In Figure 3b, only County B area is marked as an impaired location. This is because with the spectral overlap = 0 MHz the D/U threshold is now Y dB and several of the hypothetical base stations no longer cause interference, County A area no longer intersects with any 10-kilometer grid areas containing interference-causing hypothetical base stations. These calculations are performed for each DTV station and each spectral overlap value to develop a complete list of Case 3 impairment locations for use during the incentive auction.

21. **Case 4.** The area within a specified separation distance from the outer edge of the DTV station’s contour and including all area inside of the contour is divided into 2-kilometer grid cells. Each grid cell that falls within this area is noted and marked as impaired. The totality of these marked grid cells within any particular wireless license area becomes the restricted area of the wireless license. Determination of whether a grid cell is inside or outside of the specified separation distance is based on the point defined by the population centroid of the 2-kilometer grid cell or by the geometric center of the grid cell, when no population is present. Specified separation distances are based on wireless to DTV channel spectral overlap and are given in Table 8.

**A. Threshold Values for Interference from Wireless Downlink into Digital Full-Power and Class A TV Stations (Case 3)**

22. The threshold D/U ratios for interference to DTV service from wireless downlink operations for the varying amounts of spectral overlap are shown in Table 7; a predicted D/U ratio lower than the applicable value in Table 7 indicates that interference is expected in cell. OTR is set to zero in this case because the DTV receiver bandwidth is assumed to be larger than the wireless emission.

Spectral Overlap (MHz)	5	4	3	2	1	0	-1 to -5 <sup>21</sup>
Downlink to DTV D/U Required (dB)	$16 + \alpha$	$15.1 + \alpha$	$13.8 + \alpha$	$12.1 + \alpha$	$9.3 + \alpha$	$-2.0 + \alpha$	$-18 + \alpha$

Table 7. Threshold Interfering D/U Ratios for Wireless Base Station into DTV

**B. Threshold Values for Interference from Wireless Uplink into Digital Full-Power and Class A TV Stations (Case 4)**

23. Impairments caused to TV service by uplink full or partial co-channel (spectral overlaps of +5 to +1 MHz) wireless user equipment are to be determined based on a five kilometer distance restriction measured from the station's noise-limited or protected contour. Impairments due to full or partial first-adjacent-channel wireless user equipment (spectral overlaps of 0 to -5 MHz) are to be based on a 0.5 kilometer distance restriction measured from the station's noise-limited or protected contour.<sup>22</sup>

Spectral Overlap (MHz)	+5 to +1 MHz	0 to -5 MHz
Uplink to DTV Separation Requirement (km)	5	0.5

Table 8. Separation Distance requirements for Wireless UE to DTV

**C. Technical Specifications**

24. *Methodology to Define DTV Service Area.* For Case 3, service of digital full-power television stations is evaluated inside the noise-limited contour defined in 47 C.F.R. § 73.622(e), with the exception that the defining field strength threshold for UHF channels is modified by subtracting a frequency-dependent dipole antenna adjustment factor. Thus the area subject to calculation for digital full-power TV stations consists of that within the contours described by the geographic points at which the field strength predicted for 50% of locations and 90% of the time by FCC curves is at least as great as the values given in Table 9 below.<sup>23</sup>

<sup>21</sup> We assume -33 dB adjacent channel rejection for the DTV receiver and  $43 + 10 \log(P)$  in a 100 kHz bandwidth attenuation for the wireless emission mask. These flat response curves lead to a constant OFR rejection at spectral overlaps less than 0 MHz.

<sup>22</sup> See Daniel, W. and Wong, H., "Propagation in Suburban Areas at Distances less than Ten Miles," FCC/OET TM 91-1, Federal Communications Commission, Office of Engineering and Technology, January 25, 1991." Assuming 18 dBμV/m (41 dBμV/m – 23 dB) as a sufficient field strength threshold to protect co-channel DTV and 51 dBμV/m (41 dBμV/m – 23 dB + 33 dB) as a sufficient field strength threshold to protect adjacent-channel DTV, as well as outdoor propagation from user equipment operating at 23 dBm (-9.2 dBW assuming a -2.2 dBd antenna gain), with a transmit height above ground of 1.5 meters and a receive antenna height above ground of 10 meters, the resulting separation distances from the 41 dBμV/m DTV service contour are 2.8 kilometers for co-channel and 0.4 kilometers for adjacent-channel operation. While the user equipment could be higher above ground resulting in a larger separation distance, this simple analysis does not consider other factors such as building attenuation, clutter losses from other obstacles, transmit antenna inefficiencies, transmit power control, or receive antenna discrimination.

<sup>23</sup> The relevant curves for predicting these fields are the F(50, 90) curves found by the formula  $F(50, 90) = F(50, 50) - [F(50, 10) - F(50, 50)]$ , using the radio propagation curves in 47 C.F.R. § 73.699.

Channels	Defining Field Strength, dBμV/m, to be predicted using F(50, 90) curves
14 - 51	$41 - 20\log_{10}[615/(\text{channel mid-frequency in MHz})]$

Table 9. Field strengths defining the area subject to calculation for UHF digital full-power TV stations

25. For digital Class A TV stations, service is protected only inside the “protected contour” defined in 47 C.F.R. § 73.6010(c), with the exception that the defining field strength threshold for UHF channels is modified by subtracting a frequency-dependent dipole antenna adjustment factor. Thus the area subject to calculation for digital Class A TV stations consists of that within the contours described by the geographic points at which the field strength predicted for 50% of locations and 90% of time by FCC curves is at least as great as the values given in Table 10 below.<sup>24</sup>

Channels	Defining Field Strength, dBμV/m, to be predicted using F(50, 90) curves
14 - 51	$51 - 20\log_{10}[615/(\text{channel mid-frequency in MHz})]$

Table 10. Field strengths defining the area subject to calculation for UHF digital Class A TV stations

26. The values set in the Longley-Rice Fortran code implementing the Longley-Rice model accompanying the FCC’s *TVStudy* software are provided in Table 11 below. As adopted in the *Second Report & Order*,<sup>25</sup> in those cases that error code 3 occurs (KWX = 3), the predicted field strength is to be accepted as indicative of whether noise-limited field strength is available at that location.

<sup>24</sup> The relevant curves for predicting these fields are the F(50, 90) curves found by the formula  $F(50, 90) = F(50, 50) - [F(50, 10) - F(50, 50)]$ , using the radio propagation curves in 47 C.F.R. § 73.699.

<sup>25</sup> See *supra*, *Second Report & Order*, para 54.

Parameter	Value	Meaning/Comment
EPS	15.0	Relative permittivity of ground.
SGM (S/m)	0.005	Ground conductivity.
ZSYS	0.0	General System Elevation. Coordinated with setting of EN0.
EN0 (ppm)	301.0	Surface refractivity in N-units.
IPOL	0	Denotes horizontal polarization.
MDVAR	3	Calculation Mode (Broadcast).
KLIM	5	Climate Code (Continental Temperate).
XI (km)	0.1	Terrain sampling interval.
HG(1) (m)	30	Height of the radiation center above ground.
HG(2) (m)	10	Height of DTV receiver above ground
Time variability (desired signal)	90%	
Time variability (undesired signal)	10%	
Location variability	50%	
Confidence variability	50%	(Also called situational variability)
Error Code (KWX=3)	Ignore	Accept the path loss value that is returned by Longley-Rice code

Table 11. Longley-Rice parameter values for ISIX Case 3

27. *D/U Ratio Limits for Interference to DTV.* To predict impairments resulting from wireless interference to DTV service caused by wireless co-channel interference, the minimum D/U ratios are computed from the following formula:

$$\text{Wireless-into-DTV D/U} = 15 + \Delta + \alpha - \text{OFR}$$

Where:

$$\Delta = \begin{cases} 1 & \text{co-channel (spectral overlap} > 0 \text{ MHz)} \\ 0 & \text{adjacent-channel (spectral overlap} \leq 0 \text{ MHz)} \end{cases}$$

$$\alpha = 10 \log_{10} \left[ \frac{1}{(1 - 10^{-x/10})} \right]$$

$$x = S/N - 15.19 \text{ dB}$$

OFR = Off-frequency rejection (See Table 12)

The quantity x is the amount by which the actual desired S/N exceeds the minimum required for DTV reception. As the desired DTV signal level approaches the minimum level for reception, the D/U ratio will increase exponentially.

28. The D/U threshold for each spectral overlap is then adjusted by the OFR value based on the transmitter emission mask and receiver selectivity curves. The values for OFR were derived using the NTIA's MSAM FDR computer program,<sup>26</sup> using the FCC's emission limits for wireless,<sup>27</sup> and DTV

<sup>26</sup> The International Telecommunications Union (ITU) has accepted frequency-dependent rejection (FDR) as an established technique in measuring the combination of receiver selectivity and unwanted transmitter emissions for calculating distance and frequency separations at acceptable interference levels in its publication ITU-R SM.337-6 (2008), available at: [http://www.itu.int/dms\\_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf](http://www.itu.int/dms_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf). National Telecommunications and Information Administration (NTIA)'s FDR is a computer-based implementation of this widely-accepted method available in its Microcomputer Spectrum Analysis Models (MSAM) software suite. See, e.g., Communications Receiver Performance Degradation Handbook,

(continued....)

receiver performance standards published by ATSC.<sup>28</sup> The results are provided in Table 12.

Overlap in MHz OFR (dB)	5	4	3	2	1	0	-1	-2	-3	-4	-5
Full-Power and Class A stations	0	0.9	2.2	3.9	6.7	17.0	33	33	33	33	33

Table 12. Calculated Off-Frequency Rejection (OFR) values for Wireless into DTV

Parameter	Value	Comment
Emission BW (MHz)	5	
ERP (W)	720 <sup>29</sup>	Assumes 1.2 kW in 10 MHz channel with two 40 W power amplifiers.
ERP (dBm)	58.6	$= 10\log_{10}(\text{ERP}) + 30$ .
G (dBd)	12.8	Assumes 15 dBi - 2.2 (approximate dipole gain).
Antenna Pattern	Non-directional	Hypothetical base station antennas are assumed to be non-directional in the azimuth direction and are assumed to have an elevation pattern similar to the generic pattern specified for UHF DTV in OET Bulletin No. 69, Table 8.
L (dB)	1	Line loss
HG(1) (m)	30	Antenna height above ground

Table 13. Assumed wireless base station transmitting specifications

29. We recognize that wireless downlink transmitters in multiple adjacent wireless spectrum blocks can increase the potential for interference to DTV service. To offset this, we assume base station ERP based on the power in a 6 MHz channel (see Table 13 and footnote 29) and separately evaluate each 5 MHz wireless channel.

30. *TV Receiving Antenna Pattern.* For Case 3, the TV receiving antenna is assumed to have a directional gain pattern which tends to discriminate against off-axis undesired stations. This pattern is a planning factor affecting interference.<sup>30</sup> A working group of the FCC Advisory Committee for Advanced Television Service selected the specific form of this pattern. The discrimination, in relative field, provided by the assumed TV receiving pattern is a function of the angle between the lines joining the desired and undesired stations to the reception point. One of these lines goes directly to the desired station, the other goes to the undesired station. The discrimination is calculated as the fourth power of the cosine of the angle between these lines but never more than represented by the front-to-back ratio of 14 dB for UHF. When both desired and undesired stations are on the receive antenna's boresight, the angle

(Continued from previous page) —————  
<http://www.ntia.doc.gov/files/ntia/publications/jsc-cr-10-004final.pdf> at 28–31 (last visited Apr. 17, 2014); NTIA Technical Memo TM-09-461 (<http://www.its.bldrdoc.gov/publications/2498.aspx>) at 5–8, 5–9 (last visited Apr. 17, 2014); Frequency Dependent Rejection (FDR) Overview, <http://ntiacsd.ntia.doc.gov/msam/FDR/FDRoverview.htm> (last visited Apr. 17, 2014).

<sup>27</sup> See 47 C.F.R. § 27.53(g).

<sup>28</sup> See ATSC Recommended Practice A/74: Receiver Performance Guidelines, section 5.4.2, Adjacent Channel Rejection, 7 Apr. 2010, available at [http://www.atsc.org/cms/standards/a\\_74-2010.pdf](http://www.atsc.org/cms/standards/a_74-2010.pdf) (last visited May 1, 2014).

<sup>29</sup> ERP of 720 W = 120 W/MHz x 6 MHz. This adds an additional 0.8 dB of interference power in the wireless block to simulate operations of wireless base stations transmitting across contiguous adjacent wireless blocks affecting one 6 MHz TV channel.

<sup>30</sup> See OET Bulletin No. 69 at 9.

is 0.0 giving a cosine of unity so that there is no discrimination. When the undesired station is somewhat off-axis, the cosine will be less than unity and the resulting interference field strength is reduced accordingly by this value (while the desired field strength remains unchanged); when the undesired station is far off axis,<sup>31</sup> the maximum discrimination given by the 14dB front-to-back ratio is attained, and the resulting interference field strength is reduced by 14 (while the desired field strength still remains unchanged).

## V. ENGINEERING DATABASES

31. *DTV Engineering Data.* Engineering data for TV stations in the U.S. (including full-power DTV and Class A) is available from the FCC. Data for individual stations can be found at <http://www.fcc.gov/mb/video/tvq.html>, and consolidated data for all authorized stations can be found at <ftp://ftp.fcc.gov/pub/Bureaus/MB/Databases/cdbs/>. Where more than one authorization exists for a particular station, the record associated with the facility actually operating is used. Where specific elevation pattern data are not provided, a generic elevation pattern may be used as described in OET Bulletin No. 69. The generic elevation pattern should, however, be offset by the amount of electrical beam tilt specified in the CDBS. When performing inter-service interference calculations for the purpose of predicting impaired locations during the incentive auction, the CDBS dataset approved by the Commission for use in the auction will be used.

## VI. USING TVSTUDY TO RUN INTER-SERVICE INTERFERENCE ANALYSIS FOR PREDICTION OF WIRELESS MARKET IMPAIRMENTS

32. *TVStudy Parameter Settings.* *TVStudy* with parameter settings as discussed below is used to perform the inter-service interference analyses to determine impairment locations in each wireless market. The results of these analyses will be used by the auction design team to determine market impairments. The *TVStudy* settings to be used for each ISIX case are shown in Table 14 below.

General	ISIX Case 1	ISIX Case 2	ISIX Case 3
	10	10	10
			200

<sup>31</sup> Approximately 41.5° at Low VHF, 45° at High VHF, and 48.1° and UHF.

Replication	ISIX Case 1	ISIX Case 2	ISIX Case 3

CDBS	ISIX Case 1	ISIX Case 2	ISIX Case 3

Patterns	ISIX Case 1	ISIX Case 2	ISIX Case 3
Digital receive antenna f/b, UHF	0	0	14
Analog receive antenna f/b, VHF low	6	6	6

Patterns	ISIX Case 1	ISIX Case 2	ISIX Case 3
Analog receive antenna f/b, VHF high	6	6	6
Analog receive antenna f/b, UHF	0	0	6

Contours	ISIX Case 1	ISIX Case 2	ISIX Case 3
Digital full-service contour, UHF	0	0	41
Digital Class A/LPTV contour, VHF low	43	43	43
Digital Class A/LPTV contour, VHF high	48	48	48
Digital Class A/LPTV contour, UHF	0	0	51
Analog full-service contour, VHF low	47	47	47
Analog full-service contour, VHF high	56	56	56
Analog full-service contour, UHF	64	64	64
Analog Class A/LPTV contour, VHF low	62	62	62
Analog Class A/LPTV contour, VHF high	68	68	68
Analog Class A/LPTV contour, UHF	74	74	74
Use UHF dipole adjustment	Yes	Yes	Yes
Propagation curve set, digital	F(50,10)	F(50,10)	F(50,90)
Propagation curve set, analog	F(50,10)	F(50,10)	F(50,50)
Truncate DTS service area	No	No	Yes
DTS distance limit, VHF low Zone I	108	108	108
DTS distance limit, VHF low Zone II/III	128	128	128
DTS distance limit, VHF high Zone I	101	101	101
DTS distance limit, VHF high Zone II/III	123	123	123
DTS distance limit, UHF	103	103	103
HAAT radial count	8	8	8
Minimum HAAT	50	50	30.5
Contour radial count	360	360	360
Service distance limit, VHF low	0	0	0

Pathloss	ISIX Case 1	ISIX Case 2	ISIX Case 3
Longley-Rice error handling	Disregard	Disregard	Disregard
Receiver height AGL	30	1.5	10
Minimum transmitter height AGL	10	10	10
Digital desired % location	50	50	50
Digital desired % time	50	50	90

<b>Pathloss</b>	<b>ISIX Case 1</b>	<b>ISIX Case 2</b>	<b>ISIX Case 3</b>
Digital desired % confidence	50	50	50
Digital undesired % location	50	50	50
Digital undesired % confidence	50	50	50
Analog desired % location	50	50	50
<b>Service</b>	<b>ISIX Case 1</b>	<b>ISIX Case 2</b>	<b>ISIX Case 3</b>
<b>Clutter</b>	<b>ISIX Case 1</b>	<b>ISIX Case 2</b>	<b>ISIX Case 3</b>

Table 14. Study Parameter Settings

33. TVStudy ISIX Scenarios. Inter-service interference scenarios are created in TVStudy using its XML scenario import feature.

34. *ISIX Case 1 & 2 Scenarios.* For Case 1 or Case 2 impairment determinations during the auction, all CDBS DTV stations will be added to a single ISIX Case 1 or Case 2 scenario. Alternatively, if a smaller scenario is desired, this can be accomplished by identifying all CDBS stations within 500 km of a license boundary by selecting sites from *TVStudy*'s MYSQL data base and using a GIS tool or the search on radius feature of *TVStudy* with a center point selected from the center of the license boundary. Include additional distance in the radius to account for the maximum distance from license center point to license boundary, *i.e.* include additional distance equal to that maximum distance.

35. All DTV sites are to be added as “Desired Only” and replicated on channel 38. An XML scenario for ISIX Case 1 or Case 2 will look like the example shown in Figure 6 below. Other attributes can be included if desired; see the *TVStudy* Manual for more information on XML scenario format and attributes.

```

<SCENARIO NAME="ExampleScn">
  <DESCRIPTION>example scenario</DESCRIPTION>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1310956"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1250731"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1331145"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1179172"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1260424"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1450167"/>
  <SOURCE DESIRED="True" UNDESIRED="False" LOCKED="True" REPLICATE="38" CDBS_ID="1431623"/>
  .
  .
  .
</SCENARIO>

```

Figure 4. Example XML ISIX Case 1 or Case 2 scenario

36. *ISIX Case 3 Scenarios.* For Case 3 impairment determinations during the auction, scenarios are established for each license area or a grouping of license areas. This is accomplished by identifying all CDBS stations within 500 km of a license boundary by using a GIS tool or by using *TVStudy*'s search on radius feature of with a center point selected from the center of the license boundary and including additional distance in the radius to account for the maximum distance from license center point to license boundary. Create an XML scenario including all the 10-kilometer-spaced hypothetical wireless base stations within a license area of interest. Attributes for the hypothetical base stations are set as follows:

Attribute	Setting
Desired	FALSE
Undesired	TRUE
Locked	FALSE
CDBS_ID	<any integer> Must be present but not used since LOCKED=FALSE. Can be set to same integer as Facility ID
ID	<any integer> This is treated as Facility ID and it is useful to set this to a value that can be used to identify the hypothetical point.
SERVICE	DT
CHANNEL	38
CALL_SIGN	<any value>
CITY	<any value>
STATE	<any 2 letter value>
STATUS	LIC
FILE_NUMBER	<any value>
LATITUDE/LONGITUDE	NAD27 coordinates of hypothetical point. Can be given in unsigned decimal degrees or DMS_H format.
HAMSL	-999 (to have <i>TVStudy</i> calculate this value from specified HAAT)
HAAT	30
ERP	0.72
HAS_APAT	FALSE
HAS_EPAT	FALSE
EPAT_ETILT	0
EPAT_MTILT	0
EPAT_ORIENT	0

HAS_MPAT	FALSE
USE_GENERIC	TRUE

Table 15. ISIX Case 3 XML Scenario Hypothetical Transmitter Attribute Settings

37. The inter-service interference Case 3 XML scenario will look similar to the example shown in Figure 5 below. CDBS sites are listed as “desired” while all hypothetical base stations are listed as undesired only.

```

<TVSTUDY VERSION="103000">
<SCENARIO NAME="EA151">
<DESCRIPTION>ISIX Case 3 scenario example EA151</DESCRIPTION>
<SOURCE DESIRED="true" UNDESIRED="false" LOCKED="true" REPLICATE="38" CDBS_ID="194404" />
<SOURCE DESIRED="true" UNDESIRED="false" LOCKED="true" REPLICATE="38" CDBS_ID="204479" />
<SOURCE DESIRED="true" UNDESIRED="false" LOCKED="true" REPLICATE="38" CDBS_ID="270069" />
<SOURCE DESIRED="true" UNDESIRED="false" LOCKED="true" REPLICATE="38" CDBS_ID="271113" />
.
.
.
<SOURCE DESIRED="FALSE" UNDESIRED="TRUE" LOCKED="FALSE" CDBS_ID="3009931" ID="3009931"
SERVICE="DT" COUNTRY="US" CHANNEL="38" CALL_SIGN="eNB-9931" CITY="EA151" STATE="EA"
STATUS="LIC" FILE_NUMBER="FCCFileNo_9931" LATITUDE="40.4248" LONGITUDE="121.393" HAMSL="-999"
HAAT="30" ERP="0.72" HAS_APAT="FALSE" HAS_EPAT="FALSE" EPAT_ETILT="0" EPAT_MTILT="0"
EPAT_ORIENT="0" HAS_MPAT="FALSE" USE_GENERIC="TRUE" /SOURCE>
<SOURCE DESIRED="FALSE" UNDESIRED="TRUE" LOCKED="FALSE" CDBS_ID="3009934" ID="3009934"
SERVICE="DT" COUNTRY="US" CHANNEL="38" CALL_SIGN="eNB-9934" CITY="EA151" STATE="EA"
STATUS="LIC" FILE_NUMBER="FCCFileNo_9934" LATITUDE="40.155" LONGITUDE="121.393" HAMSL="-999"
HAAT="30" ERP="0.72" HAS_APAT="FALSE" HAS_EPAT="FALSE" EPAT_ETILT="0" EPAT_MTILT="0"
EPAT_ORIENT="0" HAS_MPAT="FALSE" USE_GENERIC="TRUE" /SOURCE>
.
.
.
</SCENARIO>
</TVSTUDY>

```

Figure 5. Example ISIX Case 3 XML Scenario

**APPENDIX B****FINAL RULES**

For the reasons discussed in the preamble, the Federal Communications Commission amends 47 CFR part 73 as follows:

**PART 73—RADIO BROADCAST SERVICES**

1. The authority citation for part 73 continues to read:

**Authority:** 47 U.S.C. 154, 303, 334, 336, and 339.

2. Section 73.3700 is amended by revising paragraphs (b)(1)(iv), (b)(2)(i), and (b)(2)(ii) to read as follows:

**§ 73.3700 Post-Incentive Auction Licensing and Operation.**

\* \* \* \* \*

(b) \* \* \*

(1) \* \* \*

(iv) Priority Filing Window

(A) The licensee of a reassigned station, a UHF-to-VHF station, or a High-VHF-to-Low-VHF station that, for reasons beyond its control, is unable to construct facilities that meet the technical parameters specified in the Channel Reassignment Public Notice, or the permissible contour coverage variance from those technical parameters specified in paragraph (b)(1)(ii) or (iii) of this section, may request a waiver of the construction permit application deadline specified in paragraph (b)(1)(i) no later than 30 days prior to the deadline. If its waiver request is granted, the licensee will be afforded an opportunity to submit an application for a construction permit pursuant to paragraph (b)(2)(i) or (ii) of this section in a priority filing window to be announced by the Media Bureau by public notice.

(B) The licensee of any broadcast television station that the Commission makes all reasonable efforts to preserve pursuant to Section 6403(b)(2) of the Spectrum Act that is predicted to experience aggregate new interference to population served in excess of one percent as a result of the repacking process will be afforded an opportunity to submit an application for a construction permit pursuant to paragraph (b)(2)(i) or (ii) of this section in the priority filing window required by paragraph (b)(1)(iv)(A).

\* \* \* \* \*

(2) \* \* \*

(i) Alternate channels. The licensee of a reassigned station, a UHF-to-VHF station, a High-VHF-to-Low-VHF station, or a broadcast television station described in paragraph (b)(1)(iv)(B) of this section will be permitted to file a major change application for a construction permit for an alternate channel on FCC Form 301, 301-CA, or 340 during a filing window to be announced by the Media Bureau by public notice, provided that:

\* \* \* \* \*

(ii) Expanded facilities. The licensee of a reassigned station, a UHF-to-VHF station, a High-VHF-to-Low-VHF station, or a broadcast television station described in paragraph (b)(1)(iv)(B) of this section will be permitted to file a minor change application for a construction permit on FCC Form 301, 301-CA, or 340 during a filing window to be announced by the Media Bureau by public notice, in order to request a change in the technical parameters specified in the Channel Reassignment Public Notice (or, in the case of a broadcast television station described in paragraph (b)(1)(iv)(B) that is not reassigned to a new channel, a change in its authorized technical parameters) with respect to height above average terrain (HAAT), effective radiated power (ERP), or transmitter location that would be considered a minor change under §§ 73.3572(a)(1),(2) or 74.787(b) of this chapter.

\* \* \* \* \*

## APPENDIX C

## LIST OF COMMENTERS

**For a list of commenters in GN Docket No. 12-268, see *Incentive Auction R&O*, 29 FCC Rcd 6567, Appendix D**

**List of commenters in ET Docket No. 14-14 on January 29, 2014 ISIX PN**

4G Americas  
Cohen, Dippell and Everist, P.C.  
CTIA – The Wireless Association  
Ericsson  
Linley Gumm and Charles Rhodes  
National Association of Broadcasters, ABC Television Affiliates Association, FBC Television Affiliates Association, CBS Television Network Affiliates Association, NBC Television Affiliates, the Association of Public Television Stations, the Corporation for Public Broadcasting, and the Public Broadcasting Service  
National Public Radio, Inc.  
QUALCOMM Incorporated  
Sinclair Broadcast Group, Inc.  
Society of Broadcast Engineers, Inc.  
Sprint Corporation  
Transmit Consultancy Ltd.

**List of commenters in ET Docket No. 13-26 on June 2, 2014 Aggregate Interference PN**

Block Communications, Inc., Lima Communications Corporation, Independence Television Company, WAND(TV) Partnership, Idaho Independent Television Inc., and West Central Ohio Broadcasting, Inc.  
Cohen, Dippell and Everist, P.C.  
National Association of Broadcasters  
Public Broadcasting Service, Association of Public Television Stations, Corporation for Public Broadcasting

**List of commenters in ET Docket No. 14-14 on June 20, 2014 Measurements PN**

Advanced Television Broadcasting Alliance  
Cohen, Dippell and Everist, P.C.  
DIRECTV, LLC  
National Association of Broadcasters  
Robert F. Gonsett

**APPENDIX D**  
**PROPOSED RULES**

**PART 27 – MISCELLANEOUS WIRELESS COMMUNICATIONS SERVICES**

1. The authority citation of Part 27 continues to read as follows:

**Authority:** 47 U.S.C. 154, 301, 302(a), 303, 307, 309, 332, 336, 337, 1403, 1404 and 1451  
unless otherwise noted.

2. Section 27.1310 is proposed to be added to read as follows:

**Subpart N – 600 MHz Band**

**§ 27.1310 Protection of Broadcast Television Service in the 600 MHz Band from Wireless Operations.**

(a) Licensees authorized to operate wireless services in the 600 MHz band must cause no harmful interference to public reception of the signal of broadcast television stations transmitting co-channel or on the adjacent channel.

(1) Such wireless operations must comply with the D/U ratios in Tables 7-13 in *OET Bulletin No. 74*. Copies of *OET Bulletin No. 74* may be inspected during normal business hours at the Federal Communications Commission, 445 12<sup>th</sup> St., SW, Dockets Branch (Room CY A09257), Washington, DC 20554. This document is also available through the Internet on the *FCC Home Page* at <http://www.fcc.gov>.

(2) If the 600 MHz band licensee causes harmful interference to the public reception of a signal of a broadcast television station that is operating co-channel or on an adjacent channel, that licensee must eliminate the harmful interference.

(b) Licensees authorized to operate wireless services in the 600 MHz band:

(1) are not permitted to deploy wireless base stations within noise-limited service contour or protected contour of a broadcast television station licensed on a co-channel or adjacent channel in the 600 MHz Band, and

(2) are required to perform studies to evaluate the potential for their operations to cause harmful interference to public reception of the signal of such broadcast television station using the methodology in *OET Bulletin No. 74* when they intend to deploy wireless base stations within the culling distances from the noise-limited contour or protected contour of a broadcast television station licensed on a co-channel or adjacent channel in the 600 MHz band specified in *OET Bulletin No. 74*. Licensees shall maintain records of those studies and make them available for inspection upon a claim of harmful interference to the requesting broadcasting television station or the Commission.

(c) Mobile and portable devices that operate in the 600 MHz band shall afford protection to co-channel and adjacent channel broadcast television stations in the following manner:

(1) by maintaining a minimum distance of 5 kilometers (3 miles) from co-channel broadcast television station noise-limited service or protected contours.

(2) by maintaining a minimum distance of 500 meters from adjacent-channel broadcast television station noise-limited service or protected contours (3) by not operating within the contours of a broadcast television station that is operating co-channel or adjacent channel.

(3) Licensees authorized to operate wireless services in the 600 MHz band may meet the requirements of this subparagraph by limiting their coverage to areas at least the distance prescribed by subparagraph

(c)(1) - (3) outside all noise-limited service or protected contours from co-channel or adjacent broadcast television stations.

(d) For purposes of this section, broadcast television station is defined pursuant to §73.3700(a)(1) of this chapter.

(e) For purposes of this section, co-channel operations in the 600 MHz band are defined as operations of broadcast television stations and wireless services where their assigned channels spectrally overlap.

Adjacent channel operations are defined as operations of broadcast television stations and wireless services where their assigned channels spectrally abut each other or are separated by up to 5 MHz.

## **PART 73 – RADIO BROADCAST SERVICES**

3. The authority citation of Part 73 continues to read as follows:

**Authority:** 47 U.S.C. 154, 303, 334, 336, and 339 unless otherwise noted.

4. Sections 73.3700 is proposed to be revised by adding paragraph (i) to read as follows:

### **§ 73.3700 Post-Incentive Auction Licensing and Operation.**

\* \* \* \* \*

(i) A broadcast television station licensed in the 600 MHz band, as that is defined in section 27.57(l),

(1) shall not be permitted to modify its facilities, if such modification will expand the noise limited service contour of a full power station or the protected contour of a Class A station in the direction of a wireless license area which is co-channel or adjacent channel to the broadcast television station;

(2) may request a waiver of subparagraph (a), if (i) a modification of the facilities is caused by extraordinary circumstances outside the broadcast television station's control, or, (ii) the broadcast television station cannot replicate its service area on the reassigned channel following the publication of the Channel Reassignment Public Notice.

APPENDIX E

PROPOSED OET BULLETIN No. 74

FCC/OET-74

# OET BULLETIN

OFFICE OF ENGINEERING AND TECHNOLOGY

FEDERAL COMMUNICATIONS COMMISSION

## **Longley-Rice Methodology for Predicting Inter-Service Interference to Broadcast Television from Mobile Wireless Broadband Services in the UHF Band**



**Xxxxxxxxx XX, 20XX**

**LONGLEY-RICE METHODOLOGY FOR  
PREDICTING INTER-SERVICE INTERFERENCE TO  
BROADCAST TELEVISION FROM MOBILE WIRELESS  
BROADBAND SERVICES IN THE UHF BAND**

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## I. INTRODUCTION

This Bulletin provides the methodology for prediction of interference from fixed wireless base stations in the 600 MHz downlink spectrum to digital full-power and Class A television service areas that operate co-channel or adjacent-channel to mobile wireless broadband operations. The methodology provides guidance on the implementation and use of the NTIA Institute for Telecommunications Science's Longley-Rice radio propagation model for predicting inter-service interference (ISIX) to broadcast television from mobile wireless broadband services.<sup>1</sup> Generally, co-channel interference between wireless services and broadcast television becomes unlikely if these services are geographically separated by a predetermined distance. Likewise, adjacent-channel interference becomes unlikely at a lesser distance than the co-channel case, depending on the frequency separation between the TV channel and the wireless spectrum block. Similarly, the likelihood of interference at a particular location diminishes with lower height and/or power transmitters and increases with transmitters at a higher height and/or power. For broadcast television, this methodology assumes use of the Advanced Television Systems Committee's (ATSC) Digital Television (DTV) Standard,<sup>2</sup> although it is possible, especially across U.S. international borders, that the National Television Systems Committee (NTSC) analog Television (TV) standard may also be used.<sup>3</sup> Consideration of interference predictions from fixed wireless base stations to analog television service areas is outside of the scope of this Bulletin.

The methodology uses the Longley-Rice model for predicting field strength at receive points based on the elevation profile of terrain between the transmitter and each specific reception point. Predictions can be made either over a large area (described as a 2-kilometer grid of calculation cells) or at specific locations, depending upon whether the model is configured to use its broadcast (area) or individual location (point-to-point) mode. The methodology described in this Bulletin generates predictions over large areas using the broadcast mode.<sup>4</sup> For practical reasons, a computer is needed to make these predictions because of the large amount of data required for each calculation. Computer code for Version 1.2.2 of the Longley-Rice radio propagation model (Longley-Rice model) is available at <http://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx>.

Section II of this Bulletin provides a general descriptive outline of the methodology. Section III of this Bulletin provides detailed information on defining the DTV service areas subject to interference calculation. Section IV of this Bulletin provides detailed information on evaluating potential wireless interference within those areas.

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<sup>1</sup> Version 1.2.2 of the National Telecommunications and Information Administration (NTIA) Institute for Telecommunication Sciences (ITS) Irregular Terrain Model (ITM), known as the Longley-Rice model after Anita Longley and Phil Rice who developed the original version of the model, is available at <http://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx>. The source code for this version of the Longley-Rice model, used by the Commission in several other contexts including OET Bulletin Nos. 69, 72 and 73, is available in FORTRAN, C++, and in algorithm form at the website cited above.

<sup>2</sup> See 47 C.F.R. § 73.682(d).

<sup>3</sup> For analog NTSC television transmission standards, *see, e.g.*, 28 FR 13676. Domestically, low-power television stations, including Class A and television translators, are the only remaining over-the-air broadcast television service permitted to transmit analog signals. However, they are required to cease analog operation and convert to digital by September 1, 2015. *See* Amendment of Parts 73 and 74 of the Commission's Rules to Establish Rules for Digital Low Power Television, Television Translator, and Television Booster Stations and to Amend Rules for Digital Class A Television Stations, *Second Report and Order*, 26 FCC Rcd 10732 (2011).

<sup>4</sup> See NTIA Report 82-100, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode*, G.A. Hufford, A.G. Longley and W.A. Kissick, U.S. Department of Commerce, April 1982. The broadcast (area) prediction mode is described in this report as best suited to determine the proper co-channel spacing of broadcast stations and/or wireless base stations.

## II. OUTLINE OF EVALUATION PROCEDURE

The examination of each station proceeds as follows:

- 1) The contour defining the DTV service area subject to interference calculation is determined based on the method and service thresholds provided in Section III.
- 2) The area within a station's contour is divided into cells based on a global 2-kilometer grid.
- 3) The calculation point for each cell is then determined based on the centroid of population that falls within each cell, or if the cell does not cover any population, the point is determined based on the geometric center of the cell.
- 4) The wireless base stations outside of the distance defined in Table 7 through Table 13 of Section IV are culled from the interference analysis, based on their geographic coordinates, effective radiated power (ERP) and antenna height above average terrain (HAAT).
- 5) The Longley-Rice propagation model is then applied as in Section III, Evaluation of Service, and Section IV, Evaluation of Interference.
- 6) Desired-to-undesired (D/U) ratios are determined at each cell on the global 2-kilometer grid based on the ratio of the desired TV station's predicted field strength to the root-sum-square of the predicted interfering field strengths from the wireless base stations within the culling distances.
- 7) Finally, the predicted interference at each cell in the desired station's coverage area is examined to determine if interference is predicted from any of the fixed wireless base stations within the culling distances. The appropriate minimum D/U ratio threshold for interference corresponding with the spectral overlap between the TV channel and wireless block is found in Table 5. Interference is considered harmful if any of the D/U ratios determined by the previous step are less than the appropriate minimum D/U ratio threshold in any of the populated cells on the global 2-kilometer grid within the TV station's service area.

## III. EVALUATION OF SERVICE

### A. DTV Service Area Subject to Interference Calculations

The service areas subject to interference calculation are defined in the FCC rules for both digital full-power and Class A television stations;<sup>5</sup> the rules also specify standards for determining interference to DTV service.<sup>6</sup> Because wireless services are expected to be noise-like and studies have shown that noise-like signals have interference potential nearly identical to DTV,<sup>7</sup> interference protection criteria similar to those currently used for DTV-to-DTV can generally be applied with some adjustments as discussed below.

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<sup>5</sup> See 47 C.F.R. §§ 73.622(e), 73.6010(c).

<sup>6</sup> See 47 C.F.R. § 73.623(c). See also OET Bulletin No. 69, Table 5A.

<sup>7</sup> See Stephen R. Martin, "Interference Rejection Thresholds of Consumer Digital Television Receivers Available in 2005 and 2006," FCC/OET Report 07-TR-1003, March 30, 2007. See also, "Tests of ATSC 8-VSB Reception Performance of Consumer Digital Television Receivers Available in 2005," FCC/OET Report TR-05-1017 November 2, 2005.

Under the FCC's rules, a TV station's service area is limited to the areas within certain specific field strength contours where the station's field strength exceeds a threshold value. As a result of the DTV transition, domestic full-power TV stations transmit only in digital (ATSC). As of the date of this Bulletin, Class A TV stations can be either analog or digital. However, all analog Class A facilities are currently required to cease operation by September 1, 2015.<sup>8</sup> Prediction of interference to analog television facilities is beyond the scope of this Bulletin.

For digital full-power television stations, service is evaluated inside the noise-limited contour defined in 47 C.F.R. § 73.622(e) with the exception that the defining field strength threshold for UHF channels is modified by subtracting a frequency-dependent dipole antenna adjustment factor. Thus, the area subject to interference calculation for digital full-power TV stations consists of the area within the contours described by the geographic points at which the field strength predicted for 50% of locations and 90% of the time by FCC curves is at least as great as the values given in Table 1 below.<sup>9</sup>

Channels	Defining Field Strength, dBμV/m, to be predicted using F(50, 90) curves
14 - 51	$41 - 20\log_{10}[615/(\text{channel mid-frequency in MHz})]$

Table 1. Field strengths defining the area subject to calculation for UHF digital full-power TV stations

For digital Class A TV stations, service is protected only inside the "protected contour" defined in 47 C.F.R. § 73.6010(c), with the exception that the defining field strength threshold for UHF channels is modified by subtracting a frequency-dependent dipole antenna adjustment factor. Thus, the area subject to interference calculation for digital Class A TV stations consists of the area within the contours described by the geographic points at which the field strength predicted for 50% of locations and 90% of time by FCC curves is at least as great as the values given in Table 2 below.<sup>10</sup>

Channels	Defining Field Strength, dBμV/m, to be predicted using F(50, 90) curves
14 - 51	$51 - 20\log_{10}[615/(\text{channel mid-frequency in MHz})]$

Table 2. Field strengths defining the area subject to calculation for UHF digital Class A TV stations

### B. Application of the Longley-Rice Model to Define DTV Service Area

The service area subject to interference calculation is divided into trapezoidal cells approximately 2 kilometers on a side across a global grid.<sup>11</sup> The Longley-Rice propagation model Version 1.2.2 is

<sup>8</sup> See <http://www.fcc.gov/guides/dtv-transition-and-lptv-class-translator-stations>.

<sup>9</sup> The relevant curves for predicting these fields are the F(50, 90) curves found by the formula  $F(50, 90) = F(50, 50) - [F(50, 10) - F(50, 50)]$ , using the radio propagation curves in 47 C.F.R. § 73.699. See 47 C.F.R. § 73.699.

<sup>10</sup> The relevant curves for predicting these fields are the F(50, 90) curves found by the formula  $F(50, 90) = F(50, 50) - [F(50, 10) - F(50, 50)]$ , using the radio propagation curves in 47 C.F.R. § 73.699. See 47 C.F.R. § 73.699.

<sup>11</sup> See *TVStudy Manual* at [http://data.fcc.gov/download/incentive-auctions/OET-69/2014Apr\\_TVStudyManual.pdf](http://data.fcc.gov/download/incentive-auctions/OET-69/2014Apr_TVStudyManual.pdf). The latitude size of cells is fixed for any grid type based on the specified cell size, but for a global grid the longitude size varies in steps according to latitude range (up to 75 degrees latitude). Breaks in latitude bands defining the northern and southern edges of cells are targeted to occur when the cell area changes by 2% across a band. However, incrementing the integer longitude size by a whole number of seconds will lead to an actual area change by more than 2%. For a 2-kilometer target cell size, the change in area is actually 3.25%, meaning the area of cells varies from 4.07 km<sup>2</sup> at the south edge to 3.94 km<sup>2</sup> at the north edge of a band. The actual area of each cell is to be used when cell areas are summed to determine a contour or service areas, so the changes in cell areas across a grid latitude band do not result in cumulative  
(continued....)

applied between the DTV transmitter site and a point in each cell to determine whether the predicted desired field strength is above the value found in Table 1 or Table 2, for each digital full-power or Class A TV station, respectively, based on the TV station's operating channel. For cells with population, the point chosen is the population centroid, as determined using the method implemented in the FCC's *TVStudy* software<sup>12</sup> implementing the Longley-Rice model – otherwise the point chosen is the geometric center of the cell and the point so determined represents the entire cell in all subsequent service and interference calculations. The station's directional transmitting antenna patterns (azimuth and elevation), if applicable, are taken into account in determining the effective radiated power (ERP) in the direction of each cell.

Those desiring to implement the Longley-Rice model in their own computer program to make these calculations should either download the source code available either through FCC's *TVStudy* software or through NTIA's website at <http://www.its.bldrdoc.gov/resources/radio-propagation-software/itm/itm.aspx>. However, the point chosen to determine field strength by other independent implementations of the Longley-Rice model must still be either the population centroid for cells with population or the geometric center for cells with no population. Longley-Rice parameter settings for the calculations specified in this Bulletin are shown in Table 3.

(Continued from previous page)

summation errors. Cells are referenced by their southeast corner, beginning with zero degrees latitude, zero degrees longitude.

<sup>12</sup> The FCC's *TVStudy* software provides analysis of coverage and interference of full-service digital and Class A television stations, with enhanced features and user functionality from previous versions of software implementing the Longley-Rice model. The FCC is using its *TVStudy* software in connection with the proposed broadcast television spectrum incentive auction. See <http://www.fcc.gov/document/oet-announces-release-updated-oet-69-software>. The Longley-Rice Fortran code implementing the Longley-Rice model is used in the FCC's *TVStudy* software. As the Longley-Rice Fortran code is complex, many of its options are configurable through the FCC's *TVStudy* software, available for download at <http://data.fcc.gov/download/incentive-auctions/OET-69/>. The individual installing this should have computer programming skills and experience as a system administrator of the computer system on which it is to be installed.

Parameter	Value	Meaning/Comment
EPS	15.0	Relative permittivity of ground.
SGM (S/m)	0.005	Ground conductivity.
ZSYS	0.0	General System Elevation. Coordinated with setting of EN0.
EN0 (ppm)	301.0	Surface refractivity in N-units.
IPOl	0	Denotes horizontal polarization.
MDVAR	3	Calculation Mode (Broadcast).
KLIM	5	Climate Code (Continental Temperate).
XI (km)	0.1	Terrain sampling interval.
HG(1) (m)	30	Height of the radiation center above ground.
HG(2) (m)	10	Height of DTV receiver above ground.
Time variability (desired signal)	90%	
Time variability (undesired signal)	10%	
Location variability	50%	
Confidence variability	50%	(Also called situational variability)
Error Code (KWX = 3)	Ignore	Accept the path loss value that is returned by Longley-Rice code.
Note: HG(1) is the height of the wireless transmitting antenna radiation center above ground at its specific geographic coordinates, which may be determined by subtracting the ground elevation above mean sea level (AMSL) at the transmitter location from the height of the antenna radiation center AMSL. However, if ground elevation is retrieved from the terrain elevation database as a function of the transmitter site coordinates, then bilinear interpolation between the surrounding data points in the terrain database shall be used to determine the ground elevation. Care should be used to ensure that consistent horizontal and vertical datums are employed among all data sets.		

Table 3. Longley-Rice parameter values

Terrain elevation values at uniformly spaced points between transmitter and receiver must be obtained in the manner used by *TVStudy*. That software uses a terrain elevation database with values approximately every 1 arc-second of latitude and longitude as an input. The program retrieves elevations from this database at regular intervals with a spacing increment which is chosen at the time the program is run. Based upon analysis of the effect of the terrain extraction interval on predicted field strength values compared with measured median field strength values, 0.1-kilometer spacing is to be used for terrain extraction intervals. The elevation of a point of interest is determined by bilinear interpolation of the values retrieved for the corners of the coordinate rectangle in which the point of interest lies.

#### IV. EVALUATION OF INTERFERENCE

##### A. Application of the Longley-Rice Model to Determine Interfering Signal Strength

The presence or absence of interference in each grid cell of the area subject to calculation is determined by further application of the Longley-Rice model. Radio paths between undesired transmitters and each global 2-kilometer grid point inside the service area are examined. The undesired transmitters included in the analysis of each cell are those which are possible sources of interference at that cell, considering their distance from the cell and frequency relationships. For each such radio path, the Longley-Rice model is applied for median situations (that is, confidence 50%), for 50% of locations, 10% of the time for the prediction of potential interference to TV receivers. In those cases that error code 3 occurs (KWX = 3), the predicted interfering field strength nevertheless is to be accepted in determining whether there is interference at that location.

##### B. Areas of Potential Interference

To determine whether the placement of a wireless base station at a particular location would cause interference to any TV station, information about each site in a planned wireless base station deployment is required. Specifically, actual values are required for:

- effective radiated power (ERP),
- geographic location, and
- antenna height above average terrain (HAAT)

The wireless transmit antennas may conservatively be assumed to be non-directional in both the azimuth and elevation directions, as these may be simpler to implement. However, actual antenna azimuth and elevation patterns for each planned wireless base station site may be used for increased accuracy by importing these patterns into the software implementing the Longley-Rice model and setting the azimuth orientation (N ° E, T) on a site-by-site basis.

The interference analysis for TV reception examines only those cells across the global 2-kilometer grid within the area subject to calculation that have already been determined to have a desired field strength above the threshold for reception given in Table 1 or Table 2, as appropriate. A cell on the global 2-kilometer grid is counted as receiving interference to TV if the ratio of the desired field to that of the square root of the sum of the squares (root-sum-square, or RSS) of all of an individual wireless licensee's undesired wireless interference sources within the appropriate culling distances, defined below, is less than the minimum D/U threshold value for the corresponding spectral overlap between the TV and wireless channels. The comparison is made after applying the discrimination effect of the receiving TV antenna.

##### C. DTV D/U Ratios for Co-Channel and Adjacent Channel Operations

Thresholds of interference using the ratio of desired to undesired field strength to protect DTV reception from wireless co-channel interference are computed from the following formula:

$$\text{Wireless-into-DTV D/U} = 15 + \Delta + \alpha - \text{OFR} \quad (\text{Eq. 1})$$

Where:

$$\Delta = \begin{cases} 1 & \text{co-channel (spectral overlap} > 0 \text{ MHz)} \\ 0 & \text{adjacent-channel (spectral overlap} \leq 0 \text{ MHz)} \end{cases}$$

$$\alpha = 10 \log_{10} \left[ \frac{1}{(1 - 10^{-x/10})} \right] \text{ x } = \text{S/N} - 15.19 \text{ dB}$$

OFR = Off-frequency rejection (see Table 4)

The quantity  $x$  in Equation 1 is the amount by which the actual desired S/N, computed using Equation 2 below, exceeds the minimum required for DTV reception. As the desired DTV signal level approaches the minimum level for reception, the D/U ratio will increase exponentially.

Because a 5 MHz wireless channel and a 6 MHz DTV channel may not always fully overlap, the total wireless power in the TV channel is a function of the degree of spectral overlap, expressed in integer megahertz (MHz). In Table 4, a fully co-channel scenario would correspond to 5 MHz of transmitter/receiver overlap, while a first-adjacent situation would correspond to 0 MHz of overlap. Partial co-channel overlaps correspond to values of 1, 2, 3, and 4 MHz. Negative overlap values define the amount of frequency separation between channel edges in the adjacent-channel cases. The co-channel values at 5 MHz may be used where there is more than 5 MHz of overlap. Wireless operations with frequency separations more than 5 MHz between channel edges or distance separations greater than the culling distances beyond a DTV station's noise-limited or protected contour, for full-power and Class A stations, respectively, are not evaluated for interference because the probability of interference beyond those values for each height and/or power combination specified in Table 7 through Table 13 below is unlikely.

Overlap in MHz OFR (dB)	5	4	3	2	1	0	-1	-2	-3	-4	-5
Downlink into DTV	0	0.9	2.2	3.9	6.7	17.0	33	33	33	33	33

Table 4. Calculated off-frequency rejection (OFR) values for wireless base station into DTV

The values for off-frequency rejection (OFR) were derived using NTIA's MSAM FDR computer program<sup>13</sup> using FCC's emission limits,<sup>14</sup> and DTV receiver performance standards published by ATSC for the first-adjacent channel.<sup>15</sup>

To protect DTV reception from wireless downlink interference at various degrees of spectral overlap, the minimum threshold D/U ratios are shown in Table 5. These were derived using Equation 1 and the OFR values from Table 4. Values of  $\alpha$  vary for each cell and are determined by the predicted desired field strength in each cell, the DTV planning factors of Table 6, and the S/N of Equation 2.

<sup>13</sup> The International Telecommunications Union (ITU) has accepted frequency-dependent rejection (FDR) as an established technique in measuring the combination of receiver selectivity and unwanted transmitter emissions for calculating distance and frequency separations at acceptable interference levels in its publication ITU-R SM.337-6 (2008), available at: [http://www.itu.int/dms\\_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf](http://www.itu.int/dms_pubrec/itu-r/rec/sm/R-REC-SM.337-6-200810-I!!PDF-E.pdf). National Telecommunications and Information Administration (NTIA)'s FDR is a computer-based implementation of this widely-accepted method available in its Microcomputer Spectrum Analysis Models (MSAM) software suite. See, e.g., Communications Receiver Performance Degradation Handbook, <http://www.ntia.doc.gov/files/ntia/publications/jsc-cr-10-004final.pdf> at 28-31 (last visited Apr. 17, 2014); NTIA Technical Memo TM-09-461 (<http://www.its.bldrdoc.gov/publications/2498.aspx>) at 5-8, 5-9 (last visited Apr. 17, 2014); Frequency Dependent Rejection (FDR) Overview, <http://ntiacsd.ntia.doc.gov/msam/FDR/FDRoverview.htm> (last visited Apr. 17, 2014).

<sup>14</sup> See 47 C.F.R. § 27.53(g).

<sup>15</sup> See ATSC Recommended Practice A/74: Receiver Performance Guidelines, section 5.4.2, Adjacent Channel Rejection, 7 Apr. 2010, available at [http://www.atsc.org/cms/standards/a\\_74-2010.pdf](http://www.atsc.org/cms/standards/a_74-2010.pdf) (last visited May 1, 2014).

Spectral Overlap (MHz)	5	4	3	2	1	0	-1 to -5 <sup>16</sup>
Downlink into DTV D/U Required (dB)	$16.0 + \alpha$	$15.1 + \alpha$	$13.8 + \alpha$	$12.1 + \alpha$	$9.3 + \alpha$	$-2.0 + \alpha$	$-18 + \alpha$

Table 5. Threshold interfering D/U ratios for wireless base station into DTV

**D. DTV Planning Factors**

The field strength values in Table 1 and Table 2 define the area subject to interference calculations for full-power and Class A UHF DTV stations, respectively. These field strengths are based on the DTV planning factors for UHF shown in Table 6. These planning factors are assumed to characterize the equipment, including antenna systems, used for consumer reception at fixed locations. They determine the minimum field strength for DTV reception in the UHF band.

Planning Factor	Symbol	UHF Ch 14-51
Geometric mean frequency (MHz)	F	615
Dipole factor (dBm-dBμV/m)	$K_d$	-130.8
Dipole factor adjustment	$K_a$	see text
Thermal noise (dBm)	$N_t$	-106.2
Antenna gain (dBd)	G	10
Downlead line loss (dB)	L	4
System noise figure (dB)	$N_s$	7
Required signal-to-Noise ratio (dB)	S/N	15

Table 6. Planning factors for UHF

For UHF, the dipole adjustment factor,  $K_a = 20\log_{10}[615/(\text{channel mid-frequency in MHz})]$ , is added to  $K_d$  in each case to account for the fact that field strength requirements are greater for UHF channels above the geometric mean frequency of the historically defined UHF TV band (*i.e.*, channels 14-69) and smaller for UHF channels below that mean frequency. The geometric mean frequency, 615 MHz, is approximately the mid-frequency of TV channel 38. By applying the planning factors in Table 6 and using the Longley-Rice model to predict the desired field strength “E,” the predicted signal-to-noise ratio (S/N) is then calculated from the formula:

$$S/N = E + K_d + K_a + G - L - N_t - N_s \quad (\text{Eq. 2})$$

The predicted S/N value associated with the field strength of the desired signal in each cell is used, based on the TV station’s operating channel, to determine the applicable interference threshold using Table 5 and Table 6 above.

**E. DTV Receiving Antenna Pattern**

The TV receiving antenna is assumed to have a directional gain pattern which tends to discriminate against off-axis undesired stations. This pattern is a planning factor affecting the receiver’s susceptibility to interference.<sup>17</sup> A working group of the FCC Advisory Committee for Advanced Television Service chose the specific form of this pattern. The discrimination, in relative field, provided

<sup>16</sup> -33 dB adjacent channel rejection is used for the DTV receiver and  $43+10\log P$  in a 100 kHz bandwidth attenuation is used for the wireless emission mask. These flat response curves lead to a constant OFR at spectral overlaps less than 0 MHz.

<sup>17</sup> See OET Bulletin No. 69 at 9.

by the assumed TV receiving pattern is a fourth-power cosine function of the angle between the lines joining the desired and undesired stations to the reception point. One of these lines goes directly to the desired station, the other goes to the undesired station. The discrimination is calculated as the fourth power of the cosine of the angle between these lines but never more than represented by the front-to-back ratio of 14 dB for UHF. When both desired and undesired stations are on the receive antenna's boresight, the angle is 0.0 giving a cosine of unity so that there is no discrimination. When the undesired station is somewhat off-axis, the cosine will be slightly less than unity and the resulting interference field strength is reduced accordingly by this value (while the desired field strength remains unchanged); when the undesired station is far off-axis,<sup>18</sup> the maximum discrimination given by the 14 dB front-to-back ratio is attained, and the resulting interference field strength is reduced by 14 (while the desired field strength still remains unchanged).

#### F. Identification of Potentially Interfering Stations

Potential sources of interference are identified as a function of distance for the given ERP, HAAT, and frequency relationship in terms of spectral overlap of each site in a planned wireless deployment. Spectral overlap is defined as the frequency separation between channel edges of a wireless block and DTV channel. For wireless bandwidths larger or smaller than 5 MHz, interference evaluations need only consider the separation between the occupied portions of each 5 MHz block. For example, as shown on Figure 1, for a first-adjacent wireless block/TV channel relationship (otherwise there is 0 MHz spectral overlap for the 5 MHz case) if a 3 MHz LTE signal is being deployed in a 5 MHz block, then the spectral overlap would depend on its position within the 5 MHz block (e.g., 0 MHz if in the 3 MHz nearest to TV (Figure 1a); -1 MHz if centered in the 5 MHz block (Figure 1b); or -2 MHz if furthest from TV (Figure 1c)), and the ERP would be the total in the 5 MHz channel. Similarly if the two nearest first-adjacent blocks were used contiguously to form a 10 MHz channel, there would be two associated spectral overlaps, 0 MHz and -5 MHz, and the ERP would be determined by the power in each 5 MHz block.

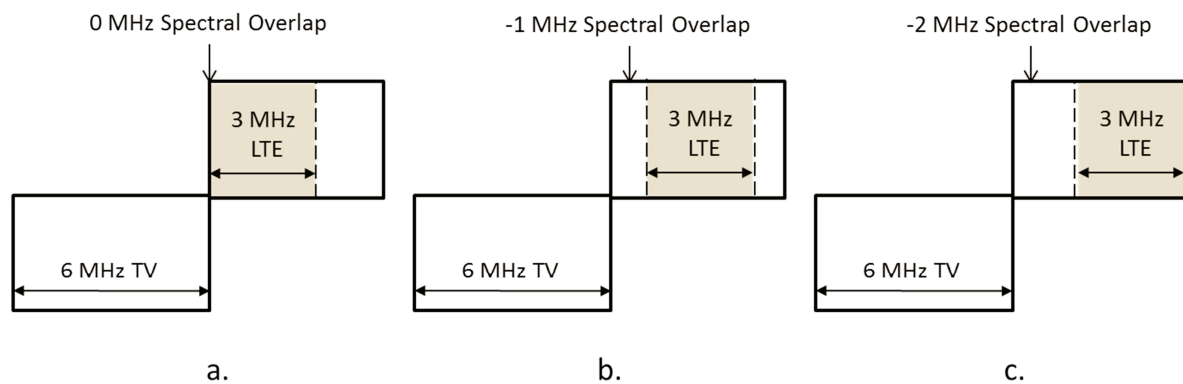


Figure 1. Examples of Spectral Overlap when LTE channel is using only a portion of 5 MHz channel

The interference analysis is performed independently for each cell in the DTV service area subject to calculation. Only those wireless base stations with transmitter sites at distances less than the culling distance (corresponding to the wireless base station ERP, HAAT, and spectral overlap) from the edge of a DTV station noise-limited or protected contour are to be considered in the interference analysis.

<sup>18</sup> Approximately 41.5° at Low VHF, 45° at High VHF, and 48.1° and UHF.

Table 7 through Table 13 specify these culling distances, which were derived based on the distance to the UHF F(50,10) {OFR (dB) + 18} dB $\mu$ V/m contour, depending on the OFR for each spectral overlap case.

HAAT (m):	ERP (kW) per 5 MHz block:								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	209	204	196	186	169	163	153	136	115
200	197	191	183	174	158	151	141	125	104
150	190	184	178	168	152	145	135	119	98
100	183	178	171	160	144	137	127	111	91
80	180	174	166	156	140	133	123	107	86
65	176	170	163	153	137	130	120	104	83
50	172	167	159	150	133	126	117	100	80
35	168	162	155	145	129	122	113	97	76

Table 7. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap  $\geq 5$  MHz)

HAAT (m):	ERP (kW) per 5 MHz block:								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	205	199	192	181	166	159	148	132	111
200	192	186	179	169	153	146	137	121	100
150	185	180	173	164	147	140	131	115	94
100	179	173	166	156	139	132	123	107	86
80	175	169	162	152	136	128	119	103	82
65	171	166	158	149	132	125	116	99	79
50	168	162	155	146	129	122	112	96	76
35	163	158	151	141	125	118	108	92	73

Table 8. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap = 4 MHz)

HAAT (m):	ERP (kW) per 5 MHz block:								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	197	191	183	173	158	150	141	124	104
200	183	178	171	162	146	139	129	113	93
150	178	172	166	156	140	133	123	108	87
100	171	165	158	149	131	124	116	100	79
80	167	161	154	145	127	121	112	96	75
65	163	158	151	142	125	118	108	92	73
50	159	154	148	138	121	114	105	89	70
35	155	150	143	133	117	110	101	85	66

Table 9. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap = 3 MHz)

HAAT (m):	ERP (kW) per 5 MHz block:								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	187	181	174	166	148	141	132	116	97
200	174	170	163	153	137	130	121	105	86
150	169	164	157	147	131	124	115	99	80
100	161	156	149	140	123	116	107	91	73
80	157	152	146	136	119	112	103	87	69
65	154	149	143	132	116	109	100	84	66
50	151	146	139	129	112	105	96	81	63
35	146	141	134	125	108	102	92	77	60

Table 10. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap = 2 MHz)

HAAT (m):	ERP (kW) per 5 MHz block:								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	171	166	160	149	133	126	116	102	87
200	159	154	147	138	121	115	105	91	75
150	153	148	141	131	116	109	100	85	69
100	146	140	133	123	108	101	92	77	63
80	142	136	129	120	104	97	88	73	60
65	139	133	126	116	100	94	84	71	57
50	135	130	123	113	97	90	81	67	54
35	131	125	119	109	93	87	78	64	51

Table 11. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap = 1 MHz)

HAAT (m):	ERP (kW) per 5 MHz block:								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	115	110	104	97	86	82	76	68	59
200	104	99	93	85	73	70	65	59	52
150	98	93	87	79	68	65	61	55	48
100	90	85	79	72	62	59	55	49	42
80	86	81	75	69	59	56	52	46	38
65	83	78	73	66	56	53	49	43	36
50	80	75	70	62	53	50	46	40	33
35	76	72	66	59	50	46	42	35	28

Table 12. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap = 0 MHz)

HAAT (m):	ERP (kW) per 5 MHz block:								
	5	4	3	2	1	0.75	0.5	0.25	0.1
305	61	59	57	53	48	46	43	37	31
200	53	52	50	47	42	39	37	32	26
150	49	48	46	42	37	35	32	28	23
100	43	42	39	37	32	30	27	23	18
80	40	38	36	33	29	27	25	21	16
65	37	36	34	31	26	25	22	18	14
50	34	33	30	28	23	22	19	15	12
35	29	28	26	23	19	17	15	13	10

Table 13. Culling distances (in km) from DTV noise-limited or protected contour (spectral overlap < 0, ≥ -5 MHz)

### G. Engineering Databases

*DTV Engineering Data.* Engineering data for TV stations in the U.S. (including full-power DTV and Class A) is available from the FCC. Data for individual stations can be found at <http://www.fcc.gov/mb/video/tvq.html>, and consolidated data for all authorized stations can be found at <ftp://ftp.fcc.gov/pub/Bureaus/MB/Databases/cdbs/>. Where more than one authorization exists for a particular station, the record associated with the facility actually operating shall be used. Where specific elevation pattern data are not provided in the engineering data, a generic elevation pattern may be used as described generally in OET Bulletin No. 69 or in the rules.<sup>19</sup> The generic elevation pattern should, however, be offset by the amount of electrical beam tilt specified in the CDBS.

<sup>19</sup> For full-power UHF DTV stations, see Table 8 of OET Bulletin No. 69. However, for Class A UHF DTV stations, see 47 C. F. R. § 74.793(d).

## APPENDIX F

## FINAL REGULATORY FLEXIBILITY ANALYSIS

1. As required by the Regulatory Flexibility Act of 1980, as amended (RFA),<sup>1</sup> an Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Notice of Proposed Rulemaking (NPRM)* in ET Docket No. 12-268.<sup>2</sup> The Commission sought written public comment on the proposals in the *NPRM*, including comment on the IRFA.<sup>3</sup> This present Final Regulatory Flexibility Analysis (FRFA) conforms to the RFA.<sup>4</sup>

**A. Need for, and Objective of, the *Second Report & Order*.**

2. In this *Second Report & Order*, the Commission addresses several outstanding issues related to the *Incentive Auction R&O*.<sup>5</sup> First, we address and reject proposals for additional limits on any new interference between television stations as result of the repacking process.<sup>6</sup> Second, we establish a methodology and the associated input values to predict inter-service interference between television and wireless services in certain areas for use during the incentive auction (ISIX Methodology).<sup>7</sup>

**B. Summary of Significant Issues Raised by Public Comments in Response to the IRFA.**

3. No comments were filed in direct response to the IRFA.

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<sup>1</sup> See 5 U.S.C. § 603. The RFA, see 5 U.S.C. § 601 – 612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996), and the Small Business Jobs Act of 2010, Public Law No. 111-240, 124 Stat. 2504 (2010).

<sup>2</sup> See *Expanding the Economic and Innovation Opportunities of Spectrum through Incentive Auctions*, GN Docket No. 12-268, Notice of Proposed Rulemaking, 27 FCC Rcd 12357 (2012).

<sup>3</sup> Additional comment on the specific proposals addressed in the *Second Report & Order* was sought with the issuance of three separate Public Notices. See *Incentive Auction Task Forces Releases Updated Constraint File Data Using Actual Channels and Staff Analysis Regarding Pairwise Approach to Preserving Population Served*, GN Docket No. 12-268, ET Docket No. 13-26, Public Notice, 29 FCC Rcd 5687 (2014). See also *Office of Engineering and Technology Seeks to Supplement the Incentive Auction Proceeding record Regarding Potential Interference Between Broadcast Television and Wireless Services*, GN Docket No. 12-268, ET Docket No. 14-14, Public Notice, 29 FCC Rcd 712 (2014); *Office of Engineering and Technology Seeks Comment on Measurements of LTE into DTV Interference*, Public Notice, GN Docket No. 12-268, ET Docket No. 14-14, DA 14-852 (2014).

<sup>4</sup> See 5 U.S.C. § 604.

<sup>5</sup> See *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Report and Order, 29 FCC Rcd 6567 (2014) (*Incentive Auction R&O*).

<sup>6</sup> See *id.* at 6651, para. 182. We adopted a 0.5 percent “pairwise” or station-to-station limit on any new interference as a result of the repacking process in the *Incentive Auction R&O*. See *id.* at 6649-51, paras. 179-81.

<sup>7</sup> See *id.* at 6605-6, paras. 82-84. We will address the specific uses to be made of the interference predictions in the forthcoming *Comment PN* on final auction procedures. See *infra* note 79.

**C. Response to Comments by the Chief Counsel for Advocacy of the Small Business Administration.**

4. Pursuant to the Small Business Jobs Act of 2010, the Commission is required to respond to any comments filed by the Chief Counsel for Advocacy of the Small Business Administration (SBA), and to provide a detailed statement of any change made to the proposed rules as a result of those comments. The Chief Counsel did not file any comments in response to the proposed rules in this proceeding.

**D. Description and Estimate of the Number of Small Entities to Which the Rules Will Apply.**

5. The RFA directs agencies to provide a description of and, where feasible, an estimate of the number of small entities that may be affected by the proposed rules, if adopted.<sup>8</sup> The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction." In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.<sup>9</sup> A small business concern is one which: 1) is independently owned and operated; 2) is not dominant in its field of operation; and 3) satisfies any additional criteria established by the SBA.<sup>10</sup>

6. *Television Broadcasting.* This economic census category "comprises establishments primarily engaged in broadcasting images together with sound. These establishments operate television broadcasting studios and facilities for the programming and transmission of programs to the public."<sup>11</sup> The SBA has created the following small business size standard for Television Broadcasting firms: those having \$38.5 million or less in annual receipts.<sup>12</sup> The Commission has estimated the number of licensed commercial television stations to be 1,388.<sup>13</sup> In addition, according to Commission staff review of the BIA Advisory Services, LLC's *Media Access Pro Television Database* on March 28, 2012, about 950 of an estimated 1,300 commercial television stations (or approximately 73 percent) had revenues of \$38.5 million or less.<sup>14</sup> We therefore estimate that the majority of commercial television broadcasters are small entities.

7. We note, however, that in assessing whether a business concern qualifies as small under the above definition, business (control) affiliations must be included.<sup>15</sup> Our estimate, therefore, likely overstates the number of small entities that might be affected by our action because the revenue figure on which it is based does not include or aggregate revenues from affiliated companies. In addition, an element of the definition of "small business" is that the entity not be dominant in its field of operation.

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<sup>8</sup> *Id.* at § 603(b)(3).

<sup>9</sup> 5 U.S.C. § 601(3) (incorporating by reference the definition of "small business concern" in 15 U.S.C. § 632). Pursuant to the RFA, the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register." 5 U.S.C. § 601(3).

<sup>10</sup> Small Business Act, 15 U.S.C. § 632 (1996).

<sup>11</sup> U.S. Census Bureau, *2012 NAICS Definitions: 515120 Television Broadcasting*, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=515120&search=2012> (last visited Mar. 6, 2014).

<sup>12</sup> 13 C.F.R. § 121.201 (NAICS code 515120) (updated for inflation in 2010).

<sup>13</sup> See FCC News Release, Broadcast Station Totals as of December 31, 2013 (rel. Jan. 8, 2014), [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2014/db0108/DOC-325039A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0108/DOC-325039A1.pdf).

<sup>14</sup> We recognize that BIA's estimate differs slightly from the FCC total given the information provided above.

<sup>15</sup> "[Business concerns] are affiliates of each other when one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both." 13 C.F.R. § 121.103(a)(1).

We are unable at this time to define or quantify the criteria that would establish whether a specific television station is dominant in its field of operation. Accordingly, the estimate of small businesses to which rules may apply does not exclude any television station from the definition of a small business on this basis and is therefore possibly over-inclusive to that extent.

8. In addition, the Commission has estimated the number of licensed noncommercial educational (“NCE”) television stations to be 396.<sup>16</sup> These stations are non-profit, and therefore considered to be small entities.<sup>17</sup>

9. There are also 2,414 LPTV stations, including Class A stations, and 4,046 TV translator stations.<sup>18</sup> Given the nature of these services, we will presume that all of these entities qualify as small entities under the above SBA small business size standard.

10. *Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing.* The Census Bureau defines this category as follows: “This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment. Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment.” The SBA has developed a small business size standard for Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing, which is: all such firms having 750 or fewer employees. According to Census Bureau data for 2007, there were a total of 939 establishments in this category that operated for part or all of the entire year. Of this total, 912 had less than 500 employees and 17 had more than 1000 employees. Thus, under that size standard, the majority of firms can be considered small.

11. *Audio and Video Equipment Manufacturing.* The SBA has classified the manufacturing of audio and video equipment under in NAICS Codes classification scheme as an industry in which a manufacturer is small if it has less than 750 employees. Data contained in the 2007 U.S. Census indicate that 492 establishments operated in that industry for all or part of that year. In that year, 488 establishments had fewer than 500 employees; and only 1 had more than 1000 employees. Thus, under the applicable size standard, a majority of manufacturers of audio and video equipment may be considered small.

12. *Wireless Telecommunications Carriers (except satellite).* The Census Bureau defines this category as follows: “This industry comprises establishments engaged in operating and maintaining switching and transmission facilities to provide communications via the airwaves. Establishments in this industry have spectrum licenses and provide services using that spectrum, such as cellular phone services, paging services, wireless Internet access, and wireless video services.”<sup>19</sup> The appropriate size standard under SBA rules is for the category Wireless Telecommunications Carriers (except Satellite). The size standard for that category is that a business is small if it has 1,500 or fewer employees.<sup>20</sup> For this

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<sup>16</sup> See FCC News Release, Broadcast Station Totals as of December 31, 2013 (rel. Jan. 8, 2014), [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2014/db0108/DOC-325039A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0108/DOC-325039A1.pdf).

<sup>17</sup> See generally 5 U.S.C. §§ 601(4), (6).

<sup>18</sup> See FCC News Release, Broadcast Station Totals as of December 31, 2013 (rel. January 8, 2014), [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2014/db0108/DOC-325039A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0108/DOC-325039A1.pdf).

<sup>19</sup> U.S. Census Bureau, 2012 NAICS Definitions: 517210 Wireless Telecommunications Carriers (except Satellite), <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=517210&search=2012> (last visited Mar. 6, 2014).

<sup>20</sup> 13 C.F.R. § 121.201 (NAICS code 517210).

category, census data for 2007 show that there were 1,383 firms that operated for the entire year.<sup>21</sup> Of this total, 1,368 firms had employment of 999 or fewer employees and 15 had employment of 1000 employees or more.<sup>22</sup> Similarly, according to Commission data, 413 carriers reported that they were engaged in the provision of wireless telephony, including cellular service, PCS, and Specialized Mobile Radio ("SMR") Telephony services.<sup>23</sup> Of these, an estimated 261 have 1,500 or fewer employees and 152 have more than 1,500 employees.<sup>24</sup> Consequently, the Commission estimates that approximately half or more of these firms can be considered small. Thus, using available data, we estimate that the majority of wireless firms can be considered small.

**E. Description of Projected Reporting, Recordkeeping, and Other Compliance Requirements for Small Entities.**

13. The *Second Report & Order* provides that, if a full power or Class A station is predicted to receive aggregate new interference above one percent on the final channel assigned to it following the repacking process, it may file an application proposing an alternate channel or expanded facilities in a priority filing window, along with a limited number of other stations that have been assigned the same priority. This opportunity will be available to any station entitled to protection in the repacking process that is predicted to experience aggregate new interference in excess of one percent, regardless of whether that station was reassigned to a new channel in the repacking process.

**F. Steps Taken to Minimize Significant Economic Impact on Small Entities, and Significant Alternatives Considered**

14. The RFA requires an agency to describe any significant alternatives that it has considered in reaching its proposed approach, which may include the following four alternatives (among others): 1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; 2) the clarification, consolidation, or simplification of compliance or reporting requirements under the rule for small entities; 3) the use of performance, rather than design, standards; and 4) an exemption from coverage of the rule, or any part thereof, for small entities.<sup>25</sup>

15. The Commission believes that applying the same rules equally to all entities in this context promotes fairness. The Commission does not believe that the costs and/or administrative burdens associated with the rules will unduly burden small entities. Moreover, the revisions the Commission adopts should benefit small entities by providing them with a safeguard in the event of aggregate new interference above one percent.

**Report to Congress**

16. The Commission will send a copy of the *Second Report & Order*, including this FRFA, in a report to Congress and the Government Accountability Office pursuant to the Congressional Review Act.<sup>26</sup> In addition, the Commission will send a copy of the *Second Report & Order*, including this FRFA,

<sup>21</sup> U.S. Census Bureau, Table No. EC0751SSSZ5, *Information: Subject Series - Establishment and Firm Size: Employment Size of Firms for the United States: 2007* (NAICS code 517210), [http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN\\_2007\\_US\\_51SSSZ5](http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_51SSSZ5).

<sup>22</sup> *Id.* Available census data do not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is for firms with 1000 employees or more.

<sup>23</sup> See *Trends in Telephone Service* at Table 5.3.

<sup>24</sup> See *id.*

<sup>25</sup> 5 U.S.C. § 603(c).

<sup>26</sup> See 5 U.S.C. § 801(a)(1)(A).

to the Chief Counsel for Advocacy of the SBA. A copy of the *Second Report and Order* and FRFA (or summaries thereof) will also be published in the *Federal Register*.

## APPENDIX G

## INITIAL REGULATORY FLEXIBILITY ANALYSIS

1. As required by the Regulatory Flexibility Act (RFA),<sup>1</sup> the Commission has prepared this present Initial Regulatory Flexibility Analysis (IRFA) of the possible significant economic impact on small entities by the policies and rules proposed in this *Further Notice of Proposed Rule Making* (FNPRM). Written public comments are requested on this IRFA. Comments must be identified as responses to the IRFA and must be filed by the deadlines for comments provided on the first page of this FNPRM. The Commission will send a copy of this FNPRM, including this IRFA, to the Chief Counsel for Advocacy of the Small Business Administration (SBA).<sup>2</sup> In addition, the FNPRM and IRFA (or summaries thereof) will be published in the Federal Register.<sup>3</sup>

**A. Need for, and Objectives of, the Proposed Rules.**

2. The FNPRM addresses issues that arise from the *Incentive Auction R&O* to repurpose a portion of the broadcast spectrum for new wireless services and proposes rules governing the interference in the 600 MHz Band following the incentive auction.<sup>4</sup> In the *Incentive Auction R&O*, we adopted a flexible band plan framework that accommodates market variation.<sup>5</sup> Market variation occurs where broadcast stations remain on spectrum that is repurposed for wireless broadband under the 600 MHz Band Plan.<sup>6</sup> The FNPRM proposes rules for the protection of broadcast services from wireless operations in the 600 MHz Band when co-channel or adjacent channel and for the protection of wireless license areas from broadcast television stations seeking to expand their contours. It proposes a methodology in OET Bulletin No. 74 for predicting when a wireless base station will cause interference to a broadcast station. It proposes to require wireless user equipment to operate outside of certain separation distances from the broadcast station contours to avoid interference to television reception. In the event that wireless operations actually cause harmful interference to television reception in the 600 MHz Band where interference was not predicted to occur, the FNPRM proposes to require wireless providers to take action to eliminate the interference. The FNPRM seeks comment on appropriate wireless licensee obligations, both with respect to technical requirements and service rules. The FNPRM also proposes to adopt the ISIX Methodology to predict whether LPTV or TV Translators will cause interference to a wireless system in the 600 MHz Band. The FNPRM also proposes use of the ISIX Methodology and inputs, as detailed in the proposed OET-74, for ensuring that wireless services that are deployed during the 39-month transition period do not cause interference to broadcast television stations that have not yet transitioned to their final channel assignments.

**B. Legal Basis.**

3. The proposed action is authorized under Sections 1, 4, 301, 303, 307, 308, 309, 310, 316, 319, 332, and 403 of the Communications Act of 1934, as amended, and sections 6004, 6402, 6403, 6404,

<sup>1</sup> See 5 U.S.C. § 603. The RFA, see 5 U.S.C. § 601 – 612, has been amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA), Pub. L. No. 104-121, Title II, 110 Stat. 857 (1996).

<sup>2</sup> See 5 U.S.C. § 603(a).

<sup>3</sup> See *id.*

<sup>4</sup> See *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268, Report and Order, 29 FCC Rcd 6567 (2014) (*Incentive Auction R&O*).

<sup>5</sup> *Incentive Auction R&O*, 29 FCC Rcd at 6605, para. 82 (discussing how the 600 MHz Band Plan can accommodate market variation to avoid restricting the amount of repurposed spectrum that is available in most areas nationwide).

<sup>6</sup> See *Incentive Auction R&O*, 29 FCC Rcd at 6604-6607, paras. 81-87.

and 6407 of Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, 126 Stat. 156, 47 U.S.C. §§ 151, 154, 301, 303, 307, 308, 309, 310, 316, 319, 332, 403, 1404, 1452, and 1454.

**C. Description and Estimate of the Number of Small Entities To Which the Proposed Rules Will Apply.**

4. The RFA directs agencies to provide a description of and, where feasible, an estimate of the number of small entities that may be affected by the proposed rules, if adopted.<sup>7</sup> The RFA generally defines the term "small entity" as having the same meaning as the terms "small business," "small organization," and "small governmental jurisdiction."<sup>8</sup> In addition, the term "small business" has the same meaning as the term "small business concern" under the Small Business Act.<sup>9</sup> A small business concern is one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the SBA.<sup>10</sup>

5. *Television Broadcasting.* This economic census category "comprises establishments primarily engaged in broadcasting images together with sound. These establishments operate television broadcasting studios and facilities for the programming and transmission of programs to the public."<sup>11</sup> The SBA has created the following small business size standard for Television Broadcasting firms: those having \$38.5 million or less in annual receipts.<sup>12</sup> The Commission has estimated the number of licensed commercial television stations to be 1,388.<sup>13</sup> In addition, according to Commission staff review of the BIA Advisory Services, LLC's *Media Access Pro Television Database* on March 28, 2012, about 950 of an estimated 1,300 commercial television stations (or approximately 73 percent) had revenues of \$38.5 million or less.<sup>14</sup> We therefore estimate that the majority of commercial television broadcasters are small entities.

6. We note, however, that in assessing whether a business concern qualifies as small under the above definition, business (control) affiliations must be included.<sup>15</sup> Our estimate, therefore, likely overstates the number of small entities that might be affected by our action because the revenue figure on which it is based does not include or aggregate revenues from affiliated companies. In addition, an element of the definition of "small business" is that the entity not be dominant in its field of operation. We are unable at this time to define or quantify the criteria that would establish whether a specific television station is dominant in its field of operation. Accordingly, the estimate of small businesses to

<sup>7</sup> 5 U.S.C. § 603(b)(3).

<sup>8</sup> 5 U.S.C. § 601(6).

<sup>9</sup> 5 U.S.C. § 601(3) (incorporating by reference the definition of "small business concern" in 15 U.S.C. § 632). Pursuant to the RFA, the statutory definition of a small business applies "unless an agency, after consultation with the Office of Advocacy of the Small Business Administration and after opportunity for public comment, establishes one or more definitions of such term which are appropriate to the activities of the agency and publishes such definition(s) in the Federal Register." 5 U.S.C. § 601(3).

<sup>10</sup> Small Business Act, 15 U.S.C. § 632 (1996).

<sup>11</sup> U.S. Census Bureau, *2012 NAICS Definitions: 515120 Television Broadcasting*, <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=515120&search=2012> (last visited Mar. 6, 2014).

<sup>12</sup> 13 C.F.R. § 121.201 (NAICS code 515120) (updated for inflation in 2010).

<sup>13</sup> See FCC News Release, Broadcast Station Totals as of December 31, 2013 (rel. Jan. 8, 2014), [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2014/db0108/DOC-325039A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0108/DOC-325039A1.pdf).

<sup>14</sup> We recognize that BIA's estimate differs slightly from the FCC total given the information provided above.

<sup>15</sup> "[Business concerns] are affiliates of each other when one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both." 13 C.F.R. § 121.103(a)(1).

which rules may apply does not exclude any television station from the definition of a small business on this basis and is therefore possibly over-inclusive to that extent.

7. In addition, the Commission has estimated the number of licensed noncommercial educational (“NCE”) television stations to be 395.<sup>16</sup> These stations are non-profit, and therefore considered to be small entities.<sup>17</sup>

8. There are also 2,414 LPTV stations, including Class A stations, and 4,046 TV translator stations.<sup>18</sup> Given the nature of these services, we will presume that all of these entities qualify as small entities under the above SBA small business size standard.

9. *Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing.* The Census Bureau defines this category as follows: “This industry comprises establishments primarily engaged in manufacturing radio and television broadcast and wireless communications equipment. Examples of products made by these establishments are: transmitting and receiving antennas, cable television equipment, GPS equipment, pagers, cellular phones, mobile communications equipment, and radio and television studio and broadcasting equipment.” The SBA has developed a small business size standard for Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing, which is: all such firms having 750 or fewer employees. According to Census Bureau data for 2007, there were a total of 939 establishments in this category that operated for part or all of the entire year. Of this total, 912 had less than 500 employees and 17 had more than 1000 employees. Thus, under that size standard, the majority of firms can be considered small.

10. *Audio and Video Equipment Manufacturing.* The SBA has classified the manufacturing of audio and video equipment under in NAICS Codes classification scheme as an industry in which a manufacturer is small if it has less than 750 employees. Data contained in the 2007 U.S. Census indicate that 492 establishments operated in that industry for all or part of that year. In that year, 488 establishments had fewer than 500 employees; and only 1 had more than 1000 employees. Thus, under the applicable size standard, a majority of manufacturers of audio and video equipment may be considered small.

11. *Wireless Telecommunications Carriers (except satellite).* The Census Bureau defines this category as follows: “This industry comprises establishments engaged in operating and maintaining switching and transmission facilities to provide communications via the airwaves. Establishments in this industry have spectrum licenses and provide services using that spectrum, such as cellular phone services, paging services, wireless Internet access, and wireless video services.”<sup>19</sup> The appropriate size standard under SBA rules is for the category Wireless Telecommunications Carriers (except Satellite). The size standard for that category is that a business is small if it has 1,500 or fewer employees.<sup>20</sup> For this category, census data for 2007 show that there were 1,383 firms that operated for the entire year.<sup>21</sup> Of this

<sup>16</sup> See FCC News Release, Broadcast Station Totals as of December 31, 2013 (rel. Jan. 8, 2014), [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2014/db0108/DOC-325039A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0108/DOC-325039A1.pdf).

<sup>17</sup> See generally 5 U.S.C. §§ 601(4), (6).

<sup>18</sup> See FCC News Release, Broadcast Station Totals as of December 31, 2013 (rel. January 8, 2014), [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2014/db0108/DOC-325039A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0108/DOC-325039A1.pdf).

<sup>19</sup> U.S. Census Bureau, 2012 NAICS Definitions: 517210 Wireless Telecommunications Carriers (except Satellite), <http://www.census.gov/cgi-bin/sssd/naics/naicsrch?code=517210&search=2012> (last visited Mar. 6, 2014).

<sup>20</sup> 13 C.F.R. § 121.201 (NAICS code 517210).

<sup>21</sup> U.S. Census Bureau, Table No. EC0751SSSZ5, *Information: Subject Series - Establishment and Firm Size: Employment Size of Firms for the United States: 2007* (NAICS code 517210), [http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN\\_2007\\_US\\_51SSSZ5](http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ECN_2007_US_51SSSZ5).

total, 1,368 firms had employment of 999 or fewer employees and 15 had employment of 1000 employees or more.<sup>22</sup> Similarly, according to Commission data, 413 carriers reported that they were engaged in the provision of wireless telephony, including cellular service, PCS, and Specialized Mobile Radio (“SMR”) Telephony services.<sup>23</sup> Of these, an estimated 261 have 1,500 or fewer employees and 152 have more than 1,500 employees.<sup>24</sup> Consequently, the Commission estimates that approximately half or more of these firms can be considered small. Thus, using available data, we estimate that the majority of wireless firms can be considered small.

#### **D. Description of Projected Reporting, Recordkeeping, and Other Compliance Requirements**

12. The *FNPRM* proposes to establish the following reporting, recordkeeping, and compliance requirements. All wireless providers that hold licenses to operate co-channel or adjacent channel to a television station would perform an interference analysis using the methodology in OET-74 prior to deploying a base station within the set culling distance. The rule proposes that wireless licensees retain the latest copy of its interference analysis for each co-channel or adjacent channel Partial Economic Area (PEA) license area where any of its base stations fall within the specified OET-74 culling distances and make the analysis available to the Commission or a subject television station upon request in cases where there are complaints of interference from either the subject television station, a station viewer or the Commission. In addition, in the event that a television station and a 600 MHz Band wireless licensee do not reach resolution of an interference complaint, the *FNPRM* proposes that they can submit a claim of harmful interference to the Commission. The *FNPRM* also proposes that when a 600 MHz Band wireless licensee files a construction notification, it use the ISIX Methodology for certain interference cases and the methodology in proposed OET Bulletin 74 in another interference case to demonstrate that it cannot serve its entire PEA service area, among other evidence. The *FNPRM* also tentatively concludes that broadcast licensees who operate in the 600 MHz Band can demonstrate non-interference to a wireless licensee’s service area by showing that a proposed modification will not expand its contour in the direction of a co-channel or adjacent channel wireless licensee. The *FNPRM* also proposes that, in the event that a wireless provider seeks to commence operations prior to the end of the 39-month transition period and there are co-channel or adjacent-channel broadcast television stations in the wireless licensee’s downlink spectrum within the culling distances specified in OET-74, the wireless provider will use OET-74 to predict whether its operations will cause harmful interference to the subject television stations. The *FNPRM* proposes to require the wireless licensee to retain the latest copy of the OET-74 study and make it available to the Commission and to a subject television station upon request if there are complaints of interference either from a subject television station, a member of the public, or the Commission.

#### **E. Steps Taken to Minimize Significant Economic Impact on Small Entities, and Significant Alternatives Considered**

13. The RFA requires an agency to describe any significant alternatives that it has considered in reaching its proposed approach, which may include the following four alternatives (among others): (1) the establishment of differing compliance or reporting requirements or timetables that take into account the resources available to small entities; (2) the clarification, consolidation, or simplification of compliance or reporting requirements under the rule for small entities; (3) the use of performance, rather

<sup>22</sup> *Id.* Available census data do not provide a more precise estimate of the number of firms that have employment of 1,500 or fewer employees; the largest category provided is for firms with 1000 employees or more.

<sup>23</sup> See *Trends in Telephone Service* at Table 5.3.

<sup>24</sup> See *id.*

than design, standards; and (4) an exemption from coverage of the rule, or any part thereof, for small entities.<sup>25</sup>

14. The proposed reporting, recordkeeping, and compliance requirements will apply to all entities in the same manner. The Commission believes that applying the same rules equally to all entities in this context promotes fairness. The Commission does not believe that the costs and/or administrative burdens associated with the rules will unduly burden small entities. Wireless providers may use either the Commission's *TVStudy* software available for free online at <http://data.fcc.gov/download/incentive-auctions/OET-69/> or their own network planning software in which they can incorporate the Longley-Rice Fortran Code included with the *TVStudy* source code, to perform the OET-74 analysis.

**F. Federal Rules that May Duplicate, Overlap, or Conflict With the Proposed Rule**

15. None.

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<sup>25</sup> See 5 U.S.C. § 603(c).

**STATEMENT OF  
COMMISSIONER AJIT PAI**

Re: *Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, GN Docket No. 12-268; *Office of Engineering and Technology Releases and Seeks Comment on Updated OET-69 Software*, ET Docket No. 13-26; *Office of Engineering and Technology Seeks to Supplement the Incentive Auction Proceeding Record Regarding Potential Interference Between Broadcast Television and Wireless Services*, ET Docket No. 14-14.

During the course of this proceeding, I have urged the Commission to implement the incentive auction in a manner that is fair to all stakeholders and to respect the laws of physics.<sup>1</sup> In my view, the portions of today's item designed to avoid inter-service interference between wireless services and broadcast television stay true to these principles. I commend the staff for their hard work on these highly technical issues.

With respect to the issue of aggregate interference, I came to this item inclined to support some type of cap. But for two reasons, I've concluded that the Commission's decision not to impose a cap is the correct one. *First*, as detailed in this item,<sup>2</sup> our staff's analysis demonstrates that few stations are likely to receive aggregate new interference above one percent as a result of the repack. And *second*, given the auction-design decisions made by the Commission in May, an aggregate cap would substantially complicate and slow down the reverse auction. To be sure, I did not agree with many of the decisions made back in May. But as Idina Menzel reminds us in the Oscar-winning song "Let It Go," "the past is in the past!"

Finally, in recent days, broadcasters have argued that as a result of channel changes, some stations could see the population they serve reduced by 6 to 10 percent following the repack. This is an important concern. However, today's item addresses whether there should be a cap on population loss caused by interference, *not* channel changes. I hope we will address that concern in a future item, but in any event will vote to approve this one.

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<sup>1</sup> See, e.g., Opening Remarks of Commissioner Ajit Pai at CTIA 2013's Panel on the Spectrum Incentive Auctions: Step Right Up!, Las Vegas, Nevada (May 22, 2013), <http://go.usa.gov/fBfC>.

<sup>2</sup> See Second Report and Order and Further Notice of Proposed Rulemaking at para. 5.